LUMONICS

MULTIFLEX OPTICAL - FIBRE BEAM - DELIVERY SYSTEM

Instruction Manual: Operation
Maintenance and Service

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INSTRUCTION MANUAL : OPERATION, MAINTENANCE & SERVICE

MULTIFLEX OPTICAL-FIBRE BEAM-DELIVERY SYSTEM

(MODULAR ENERGY/TIMESHARE - JK700)

SYSTEM SERIAL NO: 415260 DATE: 7 December 1989

MANUFACTURED BY:

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DAMAGE DURING SHIPMENT

FOR YOUR PROTECTION

The acceptance of this shipment by the transportation company at our plant is acknowledgment that it was handed over to them in GOOD CONDITION AND PROPERLY PACKED.

The transportation company that delivers this shipment to your door is responsible for its safe delivery.

If shipment has been made fob our plant, and is damaged externally:

1. Have the deliveryman note on the freight bill the nature and extent of the damages.

2. Notify the office of the transportation company who delivered the shipment to you, and request them to inspect the shipment.

3. File a claim for damages with the transportation company at once.

4. Retain all packing material until shipment is inspected and your claim is settled.

If shipment has been fob our plant, and is damaged internally:

Carry out Steps 2 to 4 above immediately upon discovery of the damages.

If shipment has been made fob our plant, and shortages have occurred:

If shipment delivered to you is not in agreement with the quantity of containers shown on your receipt, accept it only after such shortages have been noted on the freight bill or bill of lading. File a claim with the transportation company who delivered the shipment to your door at once.

Lumonics Ltd accepts no responsibility for shipments made fob our plant which are damaged or lost in transit. Claims for loss or damage MUST NOT be deducted from our invoice, or payment withheld, awaiting adjustment or settlement of such claims.

If, upon arrival of a shipment made fob our plant, you have any questions, please do not hesitate to call us.

If shipment has been made fob destination and damages or shortages have occurred:

Lumonics Ltd requests your co-operation and asks that you notify us immediately by telephone, telex or fax upon arrival of the shipment. Please carry out all of the procedures outlined above, except for those relating to the filing of claims. All documents resulting from these procedures should be mailed to Lumonics Ltd, Cosford Lane, Rugby, Warwickshire, CV21 1QN, England.

WARNING

Multiflex is designed to be used with Lumonics range of industrial Nd/YAG lasers. Certain precautions are ESSENTIAL to the SAFE operation and maintenance of high power lasers. Refer to the laser handbook for details. These precautions should be COMPLETELY understood BEFORE applying mains electrical power to the laser.

CDRH WARNING

CAUTION

USE OF CONTROLS OR ADJUSTMENTS, OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN, MAY RESULT IN HAZARDOUS (LASER) RADIATION EXPOSURE.

WARNING

The precautions and warnings outlined in Section 6.1. of this Manual MUST be read and thoroughly understood BEFORE attempting to operate a MULTIFLEX System and its associated laser. Failure to do so may result in costly DAMAGE.

SAFETY WARNING

Whenever the equipment is operated, ALWAYS assume that laser output will emerge from ALL the fibres (if fitted), --- otherwise, from all energy-share units and TAKE APPROPRIATE SAFETY PRECAUTIONS

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ATTENTION

Please refer to Section 10 (Appendix - Technical Data) for the latest information relating to this equipment

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SECTION 1

PREFACE

1.1. About This Manual

1.2. Conversion Factors

1. PREFACE

1.1 About this manual

1) The manual provides all necessary information to operate and maintain the equipment following installation and commissioning.

2) It is essential that the equipment be installed and commissioned by Lumonics engineers or by customer's engineers who have received approved training. The equipment should not be serviced or adjusted by unauthorised (untrained) personnel.

3) For servicing of the equipment, contact Lumonics or authorised agents.

4) Prior to powering up the associated laser and operating this equipment, it is important to read ALL sections of the manual to familiarise yourself with the equipment, PARTICULARLY Section 6.1. (Precautions) and Section 6.2. (Operating Instructions).

5) Every effort has been made to ensure that this manual is complete and accurate. However, due to a programme of continuous product improvement, details in this manual may not correspond exactly with the equipment delivered.

   Technical changes and details specific to this particular system are included in Section 10 - APPENDIX.

6) This manual deals solely with the MULTIFLEX Modular Energy/ Time Share system(s); other systems are described in companion manuals.

7) Since the primary application of MULTIFLEX is welding, this manual is phrased accordingly. However, it is anticipated that other applications, such as cutting, will be possible with minimal changes.

1.2 Conversion factors

S1 metric units are used throughout this handbook. Conversion factors are given below for the benefit of users more familiar with Imperial or US systems.

Length

25.4 millimeters (mm)	=	1 inch (in)
1 metre (m)	=	39.37 ins

Volume

1 litre (l)	=	0.88 quarts (qt) Imp
	=	1.06 quarts (qt) US
28.4 millilitres (ml)	=	1 fluid ounce (fl oz) Imp
	=	1 fluid ounce (fl oz) US

Mass

1 kilogramme (kg) = 2.20 pounds (lb)

Pressure

1 bar = 14.50 pounds force/square inch (lbf/in^2)
= 0.99 atmospheres (atm)
= 1.02 kilogrammesforce/square centimetre (kgf/cm^2)

S1 Unit Multiples

Prefix	Value	Symbol
Giga-	10^9	G
Mega-	10^6	M
Kilo-	10^3	k
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ
nano-	10^{-9}	n
pico-	10^{-12}	p

SECTION 3

SAFETY PRECAUTIONS

3.1. Electrical system

3.2. Laser system

3.3. Solvents

3.4. Safety labels (worldwide except N America)

3.5. Safety labels (N America)

3. SAFETY PRECAUTIONS

3.1 Electrical system

1) Voltages within the MULTIFLEX equipment are unlikely to exceed the supply-line voltages. Nevertheless, such voltages are potentially lethal and due caution should be exercised.

2) In particular, it is essential that servicing is carried out only by authorised and competent personnel.

3) Never guess or assume polarity or connections of wiring. NEVER use trial-and-error techniques. ALWAYS refer to circuit diagrams or consult Lumonics.

3.2 Laser system

The laser system used in conjunction with a MULTIFLEX system, is a high-power device which is categorised in the most potentially-dangerous group - Class 4 (IV).

The laser output can cause irreparable damage to EYES if viewed directly, or indirectly by diffuse reflection. Moreover, Class 4 lasers may cause skin injuries and could constitute a fire hazard. Their use requires safe procedures carried out by trained personnel.

For a full description of safety categories, refer to the suggested reading material in (7) of this section. The following information is offered as a guide:

CLASS 4 (IV) - any system capable of more than $10^5 J/m^2$ output (4J in a 7 mm diameter beam)

CLASS 1 (I) - output must not exceed $3.5 \times 10^{-3} T^{0.75}$ J over an area 80 mm in diameter ie a maximum of 1.11×10^{-4}J at 10mS pulse and a wave length of 1064 nm. This is satisfied by a laser light-tight enclosure using 'protective' film in the viewing window. The film must be sandwiched between suitable polycarbonate material to protect it against physical damage. The window must be sited in a position such that maximum Class 1 energy levels cannot be exceeded. Any access doors must be interlocked into the shutter circuit using approved safety switches. (As recommended for general machine tools in British Standards Code of Practice BS5304 or equivalent.) Access to the shutter circuit for interlock purposes is available (see Laser Manual) and 'protective' film can be purchased from Lumonics. (Please specify 'protective' film for 1064 nm; this has an optical density of 10.)

When operating the MULTIFLEX system without a Class 1 work enclosure or during servicing on a system fitted with an enclosure, the following precautions must always be observed to minimise the risk of eye damage.

REMEMBER - the light is INVISIBLE - and no protection is available from the eye blink-reflex.

1) Eye protection, suitable for use at 1064 nm wavelength, should be worn

- when panels and covers are removed from the laser or the MULTIFLEX system and the laser is energised for maintenance or service,
- when the focussing heads are operated other than in a Class I work-enclosure.

2) During maintenance or service, or operation of the focussing heads outside a Class I work-enclosure, ensure adequate precautions are taken to prevent unauthorised and unprotected personnel from entering the equipment area when the laser is operating. This can be achieved by fitting an interlock to the work-area entry-door and connecting the door interlock into the laser power-supply interlock circuit and/or providing warning signs.

3) Ensure that, wherever possible, focussing heads are

- held securely,
- pointing downwards, rather than horizontally or upwards,
- not at eye-level of personnel if possible.

4) The beam-path beyond focussing heads should be terminated, rather than allowing the beam to propagate into free-space, when no workpiece is in position. The beam-stop should be able to withstand exposure for a short time.

5) On systems with an interlocked work-enclosure NEVER override the safety interlock, even for servicing purposes.

6) For further detailed advice relating to this equipment, refer to Section 6.1.4.

7) For further guidance on the safe use of laser equipment, the following is a list of suggested reading material.

RADIATION SAFETY OF LASER PRODUCTS AND SYSTEMS (A guide for protection of personnel against hazards from laser radiation).
Part 1 - General
Part 2 - Manufacturers Requirements
Part 3 - Guidance for Users
BS4803; 1983 British Standards Institution
(available from B.S.I., Linford Wood, Milton Keynes, MK14 6LE, England)

LASER SAFETY HANDBOOK
A Mallow & L Chabot
Van Nostrand Reinhold Co., 1978

SAFETY IN UNIVERSITIES : NOTES OF GUIDANCE (PART 2:1 LASERS)
(Association of Commonwealth Universities for the Committee of Vice-Chancellors & Principals, 29 Tavistock Square, London WC1H 9EZ).

LASER SAFETY GUIDE - Laser Institute of America
Available from 5151 Monroe Street, Toledo, OH 43623, USA

AMERICAN NATIONAL STANDARD FOR THE SAFE USE OF LASERS
(ANSI Z1316.1 - 1986)
Laser Institute of America, 5151 Monroe Street, Toledo, OH 43623, USA.

In the USA, laser equipment must conform to the requirements of the Radiation Control for Health and Safety Act of 1968, Chapter 21 CFR, Parts 1040.10.

Compliance is monitored by the Center for Devices and Radiological Health (CDRH).

Further details can be obtained from:

US Dept of Health & Human Services
Food and Drug Administration Section
Center for Devices & Radiological Health (Dept HFZ-300)
8757 Georgia Avenue
Silver Spring, MD 20910, USA

Users are strongly advised to obtain a copy of their local safety regulations relating to the use of lasers; to read, digest and implement the regulations.

3.3 Solvents

The following solvent - used when maintaining the equipment - can be injurious to health unless adequate precautions are taken:

PROPAN-2-OL (IPA)

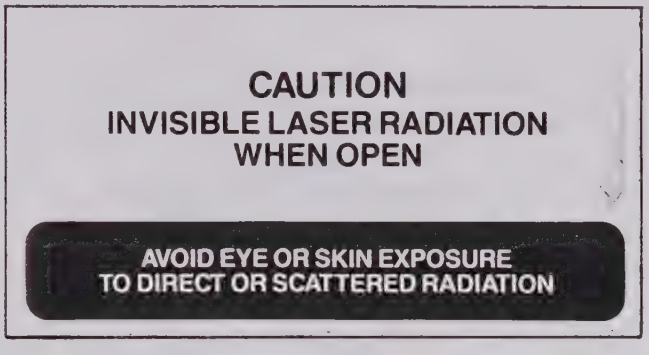
Also known as ISOPROPANOL; and ISOPROPYL ALCOHOL. IPA is a degreasing solvent recommended for cleaning optics.
Highly inflammable.
Keep container tightly closed; keep it away from sources of ignition; no smoking!
Avoid breathing vapour and contact with eyes

No other solvents are recommended.

3.4. Safety labels (worldwide except North America)

Safety labels are fitted to the equipment in compliance with applicable safety standards. Labels must not be removed or defaced. Immediately replace missing/damaged labels: replacements are available from Lumonics;

1) Non-interlocked protective housing labels



labels of this type are fixed:

- on steering mirror module(s)
- on the FESM above part J1 (where fitted)
- on each rear input module

Smaller versions of the same label are fitted around both ferrules (input and output) of each fibre assembly.

2) Aperture Label

Two Aperture labels are fixed on each focussing head, adjacent to the fibre assembly.

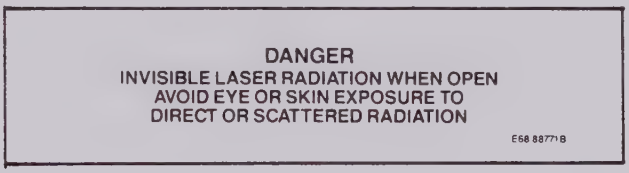
NOTE: When an integral helium-neon laser is fitted, the words "invisible laser radiation" are replaced by "visible and invisible laser radiation".

3.5 Safety labels (North America)

Systems entering the USA must comply with the provisions of the US Department of Health & Human Services (CDRH) Regulations 21 CFR 1040.10 relating to the enforcement of the Radiation Control, Health and Safety Act of 1986.

In compliance with these requirements, the following labels are fixed to the product in the locations specified. Safety labels must not be defaced or removed. Immediately replace missing/damaged labels. Replacements are available from Lumonics;

1) Non-interlocked protective housing labels



Labels of this type are fixed:

- on steering mirror module(s)
- on the FESM above part J1 (where fitted)
- on each rear input module

Smaller versions of the same label are fitted around both ferrules (input and output) of each fibre assembly.

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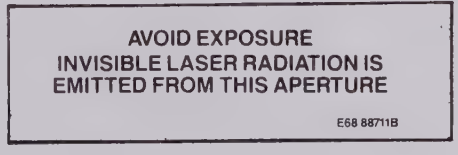
Two Aperture labels are fixed on each focussing head, adjacent to the fibre assembly.

NOTE: When an integral helium-neon laser is fitted, the words "invisible laser radiation" are replaced by "visible and invisible laser radiation".



SECTION 4

TECHNICAL DATA; INSTALLATION GUIDANCE

4.1 Specification

4.2 External service requirements

- 4.2.1 Electrical
- 4.2.2 Compressed Air
- 4.2.3 Other

4.3 Installation guidance

- 4.3.1 Focussing heads (temperature; impact)
- 4.3.2 Fibre-assemblies (bend; twist; temperature)

4. TECHNICAL DATA; INSTALLATION GUIDANCE

4.1 Specification

MULTIFLEX energy-share systems may be fitted to any standard Lumonics JK Division industrial laser and, when fitted with the correct fibre, can be used within the full specified range of laser output power and pulse energy. For details of laser type, fibre size/length and any limitations of duty, see appendix (Section 10).

Number of Fibres	up to 4 (Energy Share only) up to 8 (Time Shareor combinedTime/ Energy Share)
Minimum Bend Radius	20 cm
Heat Dissipation (Focussing Head)	10% of mean transmitted power

4.2 External service requirements

4.2.1 Electrical

24 V D.C. Switched to control Time Share module actuators.

4.2.2 Compressed Air

3-3.5 Bar lubricated compressed air supply for powering Time Share actuators.

4.2.3 Other

Processing parts may call for additional external services, principally argon gas shielding and possibly fume extraction.

4.3 Installation guidance

4.3.1 Focussing heads

1) Temperature

Maximum temperature of focussing head MUST not exceed 50°C. Accordingly focussing heads should be clamped into metal holders which have

- good thermal contact through a significant contact area
- adequately-low thermal-impedance and a significant surface area

Ideally, mounting arrangements should be capable of dissipating 10% continuously so as to prevent the temperature of focussing heads exceeding 50°C during continuous operation of a single head. Where the machine configuration automatically ensures that the laser output is shared between more than one fibre, then the heat dissipation requirement can be down-graded accordingly. Suitable clamps and/or advice are available from Lumonics.

2) Impact

Output ends of fibre assemblies and focussing heads should not be subjected to severe acceleration or deceleration such as would be caused by dropping them, hammering them or banging them on substantial objects.

4.3.2 Fibre assemblies

1) Bends

Bends should be spread over as long a length of fibre as possible, to increase the bend radius, and to minimise the rate of change of any bends. Bend radius should never be less than 20 cm.

2) Twist

Fibres should not intentionally be subjected to twist. Care should therefore be exercised as to the motions to which focussing heads are subjected.

3) Temperature

Fibre assemblies must not be allowed to read temperatures in excess of 50°C.

SECTION 5

DETAILED DESCRIPTION

5.1 Introduction

5.2 Distributor Units

- 5.2.1 General description (Energy Share Unit)
- 5.2.2 General description (Time Share Unit)
- 5.2.3 General descripton (Combination Units)
- 5.2.4 Alignment features
- 5.2.5 Time Share Actuators

5.3 Fibre assemblies

5.4 Focussing heads

- 5.4.1 General
- 5.4.2 Cooling

5. DETAILED DESCRIPTION

5.1 Introduction

The Multiflex modular energy/time share system can be configured in a number of different ways:-

1) A dedicated energy share unit fitted with up to four fibres.
2) A dedicated Time Share unit fitted with up to eight fibres.
3) Combination units which may be fitted with up to 8 fibres of which no more than four may be energy share and the rest time share.

Any system will comprise

- a modular distributor unit
- a variable number of fibre assemblies
- an equal number of focussing heads
- Alignment aids

For details of individual equipment mix fitted to this system see appendix 10.

At present, Multiflex is used primarily for welding and so, text is worded accordingly, but there is no reason why the system could not be applied to cutting and allied tasks, with minor modifications.

5.2 Distributor Units

5.2.1 General description (Energy Share Unit)

The energy share distributor unit interfaces between the laser and the fibre assemblies. It serves two purposes - it reduces the laser beam to a size small enough to enter the fibres and it provides a means of sharing the energy of the beam simultaneously between the fibres. Beam reduction is affected by means of a positive lens. A number of traversing mirrors placed in sequence provide the means of energy sharing by diverting segments of the beam.

The energy share unit is made up for four basic modular assemblies:

- A beam steering mirror module (SMM)
- An alignment telescope
- Variable energy-share modules (VESM)
- A fixed energy-share module (FESM)

Note that the number of VESM's fitted to any unit will vary with the number of fibres provided. The number of VESM's will always be one less than the total number of fibres.

The way in which these basic assemblies are built up into an energy share unit is shown diagramatically in figure 5.2A.

The SMM is fixed to the laser via a clamp boss which is secured to the laser front plate by three screws. A spigot on the SMM fits into the boss and is clamped by a single pinch-bolt.

Steering mirror 'M1' lies on the input axis of the SMM and reflects the incoming laser beam through 90° to pass along the axis of the VESM's and the FESM.

Refer to figure 5.2B.

Each VESM has a manually operating traversing mirror M2 which, when introduced into the beam, reflects it through a further 90° to pass through input lens L. Lens L focusses the laser beam to the diameter required to couple into the particular fibre optic size fitted. This focus is adjusted to be co-incident with the input end of the optical fibre.

Each traversing mirror M2 is capable of being moved up into the beam from below while maintaining the angle of incidence constant. As the edge of the mirror intercepts the beam a segment of the beam is reflected into the associated focus lens as described above. Further movement of the mirror increases the amount of the beam that is intercepted until, finally, the whole beam will be reflected into the lens and its associated fibre.

Adjustment of all the VESM's fitted allows segments of the beam to be intercepted in sequence, with any remaining part of the beam being reflected into the final focus lens L by the fixed mirror M3 of the FESM.

The energy in the beam may be shared equally between all fibres or in whatever proportion is required by the user.

Each VESM has a counter built into the mirror slide operating knob which provides an arbitrary scale for repositioning or calibration of the mirror position.

To the front of each VESM/FESM is fixed an input module (figure 5.2C) which contains the focus lens and its adjusters and provides the means of attaching the individual fibres in the correct relationship to their focus lenses. The front module body contains the lens which is retained in place by the rear module body to which the fibre is attached.

N.B. In all systems the first and second energy share modules (could be VESM or FESM) are secured to the laser front plate by fixing screws located in the rear of the modules.

5.2.2 General Descripton (Time Share Unit)

The Time Share distributor unit interfaces between the laser and the fibre assemblies. It serves two purposes - it reduces the laser beam to a size small enough to enter the fibres and it provides a means of switching (time-sharing) the laser beam sequentially between the fibres. Beam reduction is affected by means of a positive lens. A number of switchable mirrors driven by individual actuators provide the means of time-sharing by diverting the laser beam into individual fibres as required.

The time share unit is made up of four basic modular assemblies:-

- A beam steering mirror module (SMM)
- An alignment telescope
- Time Share modules (TSM)
- A fixed energy-share module (FESM)

Note that the number of TSM's fitted to any unit will vary with the number of fibres provided. The number of TSM's will always be one less than the total number of fibres.

The way in which these basic assemblies are built up into a time share unit is shown diagramatically in figure 5.2F.

The SMM is fixed to the laser via a clamp boss which is secured to the laser front plate by three screws. A spigot on the SMM fits into the boss and is clamped by a single pinch-bolt.

Steering mirror 'M1' lies on the input axis of the SMM and reflects the incoming laser beam through 90° to pass along the axis of the TSM's and the FESM.

Refer to figure 5.2G.

Each TSM has a pneumatically operating traversing mirror M2 which, when introduced into the beam, reflects it through a further 90° to pass through input lens L. Lens L focusses the laser beam to the diameter required to couple into the particular fibre optic size fitted. This focus is adjusted to be co-incident with the input end of the optical fibre.

The TSM mirror has only two fixed positions either fully intercepting the laser beam or completely out of the beam.

Unlike the VESM module, used for energy sharing, the TSM mirror does not have stable intermediate positions where it partially intercepts the beam. Indeed the laser will normally be inhibited from firing or the laser shutter closed during the transient actuation period when the mirror is moving from one position to the other.

When all TSM mirrors are in the out position (ie <u>not</u> intercepting the beam) then the complete laser beam passes into the FESM (M3) and is coupled into the fibre attached to that module.

To the front of each TSM/FESM is fixed an input module (figure 5.2C) which contains the focus lens and its adjusters and provides the means of attaching the individual fibres in the correct relationship to their focus lenses. The front module body contains the lens which is retained in place by the rear module body to which the fibre is attached.

N.B. In all systems the first and second modules (could be TSM or VESM) are secured to the laser front plate by fixing screws located in the rear of the modules.

5.2.3 General Descripton (Combination Units)

Combination units consist of a mixture of time share and energy share modules and are used where it is necessary to switch between one or more single fibres and an energy share unit on a time sharing basis. Up to four single fibres may be combined with an energy share unit of up to four ways (ie a total of eight fibres in all).

The unit will consist of a standard energy share distributor unit with the required number of time share modules (TSM) fitted between the steering mirror module (SMM) and the first variable energy share module (VESM).

Where any TSM is intercepting the laser beam the whole laser output will be coupled into the fibre attached to that TSM. If all the TSM's are in the out positon the beam will pass into the VESM/FESM combination and be shared between these fibres according to the VESM settings.

5.2.4 Alignment features

In order to facilitate correct setting up and alignment the distributor unit is provided with a number of adjustments and alignment aids.

1) To align the beam with the axis of the TSM'S/VESM's/FESM the mirror M1 in the SMM is provided with two adjustments. Refer to figure 5.2D.

   The mirror is glued to a backing plate which in turn is, screwed to the tilt plate of an adjusting mount. This pivots about a vertical axis in the outer ring of the adjusting mount and is rotated by the action of a single, spring-opposed adjusting screw S2. The outer ring is rotated about a horizontal axis by two opposed adjusting screws S1A and S1B. The adjusting mount is held in place in the SMM by the base plate of the alignment telescope. (Figure 5.2A).

2) The alignment telescope fits onto the side of the SMM; it can see through the mirror M1 (a dichroic mirror with high reflectivity at the Nd/YAG wavelength but lower reflectivity at visible wavelengths). Accordingly a sharp image of each fibre end can be formed by the associated focus lens L via the individual mirrors (M2/M3) in the TSM/VEMS/FESM. The telescope is infinity corrected by an objective lens fitted in a cell secured in the body of the telescope mounting. The lens cell has a range of axial movement and is secured by a single socket headed screw accessed through a cover beneath the telescope mount. Axial adjustment of the lens allows the telescope focus (via lenses L) to be adjusted into the same plane as the laser focus.

   The lens is also provided with a centering adjustment which allows the laser focus to be adjusted to be concentric with the graticule of the telescope. This centering adjustment is via four opposed grub screws in the front of the telescope body.

The telescope is fitted with a safety viewing filter; before the telescope is used with the laser in operation the filter should be checked to ensure that it is in good condition.

3) In order to align the reflected beam from each TSM/VESM/FESM mirror so that it passes coaxially through the focus lens the mirror assembly baseplate is adjustable in two angular directions. Each base plate is mounted on three pads within the module, secured by three fixing screws, one in the centre of each pad. The plate can rotate about one corner screw, clearance being provided between the baseplate and the other two; this screw provides one angular adjustment in the vertical plane. The second adjustment, in the horizontal plane, is provided by altering the thickness of shims fitted between the baseplate and the fixing pad beneath one of the top fixing screws.

4) In order to align the reflected beam to centre the beam in each focus lens the front input module body containing the lens is adjustable. Its mounting flange is provided with oversize holes so that it can be moved vertically and horizontally and then fixed in the correct position.

5) In order to align the laser focus exactly with the end of the fibre each individual focus lens is provided with a centering adjustment. This consists of four oposed set screws which move the lens, in its mount, within the front module body of the input module.

Axial adjustment of the fibre position is by means of spacer washers placed between the input ferrule and the rear module body of the input module.

6) Two detachable alignment aids are also provided. The first is an alignment tube with an alignment jig at each end. This replaces the rear input module body while the TSM/VESM/FESM mirrors and the front input modules are adjusted, and determines the axis to which the beam is aligned.

The second is a kapton film module which replaces the rear input module during alignment. The purpose of the module is threefold: to determine the focus position of the laser beam and to adjust the telescope focus and the telescope graticule centering to co-incide with the beam focus.

The kapton film module (see figure 5.2E) consists of a tube in which slides the kapton film holder. The holder consists of two parts which clamp a piece of film between them. The tube is eccentric to the axis of the focus lens so that rotation of the holder allows a series of holes to be drilled by the lser in the film along a circular path. If the holder is advanced axially between shots the holes will change in size reaching a minimum as the film passes through the focus. This allows the focus position to be determined. A setting ring provides a stop for the film holder so that, once the focus position has been determined, the film holder can be removed to change the film and then replaced at the set-focus position. A hole drilled in

the film at the correct focus postion can then be used to set up the alignment telescope. This procedure is fully described in section 8 of the manual.

To avoid contamination of the focus lens a replaceable cover glass is fitted at the lens end of the kapton film module (KFM).

For reasons of safety a protective cap is provided at the other end of the tube. It should always be in place when taking burns on kapton film.

5.2.5 Time Share Actuator

The TSM module consists of two parts, the module body and the actuator. The module body contains the mirror, slide and mirror alignment adjustors. The actuator is fitted below the module body and move the mirror by means of a push-rod. The rod is sealed at the interface of body and actuator with a plastic bellows to prevent dust etc entering the optics. The actuator contains; a pneumatic cylinder connected directly to the push rod which provides the motive force; a pair of lever operated dampers for reducing end of travel shock; positive break limit switches for interlocking of work enclosures; micro-switches which allow gating of laser output during transit of the mirror; a solenoid valve which controls the preumatic cylinder.

The pneumatic cylinder requires a lubricated air supply with the pressure regulated within the range of 3.0-3.5 bars. The solenoid valve works on 24v D.C. When the solenoid is energised the mirror will move into the up position where it intercepts the beam and couples it into the fibre fitted to the module.

For details of interlock connections etc see section 6.1.5.

5.3 Fibre assemblies

The essential features of the fibre assemblies are shown in Figure 5.3.

The optical fibre itself has minimal integral protection (silicone-rubber, with a nylon overjacket), to provide some mechanical protection against scratches, but principally, to exclude moisture. Both can have degrading effects on the fibre.

Mechanical protection for the fibre is provided by a loose-fit conduit, comprising an inner nylon tube, surrounded by a multiple strand helical steel sheath with a plastic overjacket. The conduit principally protects against overstretching and shear. Because the conduit offers some resistance to twist and short-radius bends, it offers limited protection in these areas too. However, DO NOT assume that the conduit will always protect the fibre against mechanical abuse. DO NOT assume that if the conduit can tolerate abuse, so can the fibre.

Fibre assemblies should not be subjected to mechanical forces other than pure bending; and machine designs and particularly, focussing head motions, should be chosen with this in mind. Bends should have

the largest possible radius of curvature and also minimum RATE OF CHANGE of curvature. Clamping of fibre assemblies should be such as to allow unavoidable twisting to be distributed over as long a length as possible.

NOTE If the fibre input ferrule is unclamped then the very precise alignment of the fibe to the laser focus will be disturbed. If this should happen the laser should not be fired down the fibre again without re-checking the alignment first. see section 8.4.

The input and output ferrules of the fibre assembly are identical and the fibre can be fitted either way round. The ends of the conduit (1) are fitted with threaded stainless steel terminators (2) onto which the input/output ferrule assemblies are screwed and locked by the locking collar (3). A set screw (4) secures the internal parts of the ferrule assembly in the correct position. This set screw and the locking collar should not be disturbed. (Any attempts to disassemble the fibre assembly by untrained personnel will result in irreparable damage.)

Fibre beads (5) are glued onto the bare fibre after polishing. The fibre is then threaded through the conduit, the beads preventing the polished end from being damaged by contact with the conduit walls. The sleeve (6) is then attached to the beads via set screws (7) and the outer sleeve (8) is fitted over and secured to both sleeve and conduit terminator.

Fibres should not be subjected to temperatures above 50°C.

5.4 Focussing heads

5.4.1. General

The basic elements of a typical focussing head are shown in Figure 5.4

The focussing head -basically a cylindrical aluminium tube - accommodates the output ferrule of a fibre-assembly at one end and the output optics and cover slide at the other end.

Output optics generally comprise two lenses (L1 and L2) held in a single lens cell by means of a spacer and lock ring. A range of different size and strength lenses is available to suit different applications, in some instances there may be a combination of three lenses. See appendix (Section 10) for details of output optics fitted to this system. The lens cell containing the output lenses is externally threaded and screws into the end of the focussing head. The protective cover slide is held on the end of the lens cell by means of a spring clip.

The purpose of the output optics is to transform the divergent beam leaving the fibre exit-face, into a convergent focussed beam. L1 and L2 can be regarded either as a pair of imaging lenses or as a recollimating lens (L1) followed by a focussing lens (L2).

The purpose of the cover slide is to protect output optics from backspatter and fume generated at the weld zone on the workpiece.

Ordinarily cover-slides would be expected to soil more quickly at higher pulse energy.

In summary then, factors determining choice of output optics include

- cover slide life
- ease of access (proximity) to workpiece
- size of workpiece
- size of weld required
- workpiece composition

5.4.2. Cooling

Note that focussing heads require some degree of heat removal, in order to meet the requirement that the operating temperature should not exceed 50°C. Measurements in still air indicate that a thermally isolated (but NOT insulated) focussing head operated continuously at 100W mean input, would reach 47°C above ambient, ie 71°C for an ambient of 24°C. Hence the need for assistance in dissipating heat from heads which are liable to be operated continuously at maximum power.

In order to dissipate the heat then,

> ideally focussing heads should have good thermal contact (across a satisfactory contact area) with a metal structure which has fairly large cross-sections (to ensure good heat flow) and significant surface area (to dissipate the heat). In the case of larger diameter focussing heads designed for use upt to 400 watts provision has been made for the attachment of a water cooled manifold block to the focussing head if necessary. This part and advise on fitting may be obtained from Lumonics.

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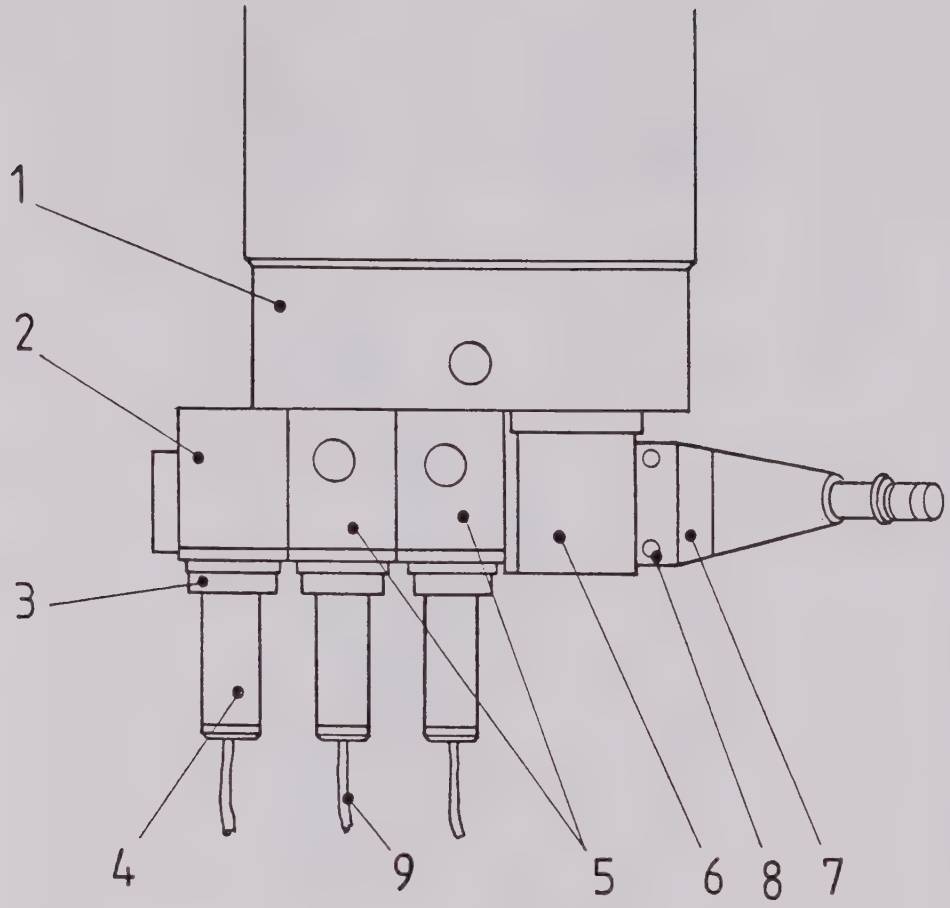

1. Laser
2. Fixed Energy Share Module
3. Front Input Module
4. Rear Input Module
5. Variable Energy Share Module
6. Steering Mirror Module
7. Alignment Telescope
8. Telescope Lens Centering Screws
9. Fibres

Fig. 5.2A DIAGRAM OF ENERGY SHARE UNIT

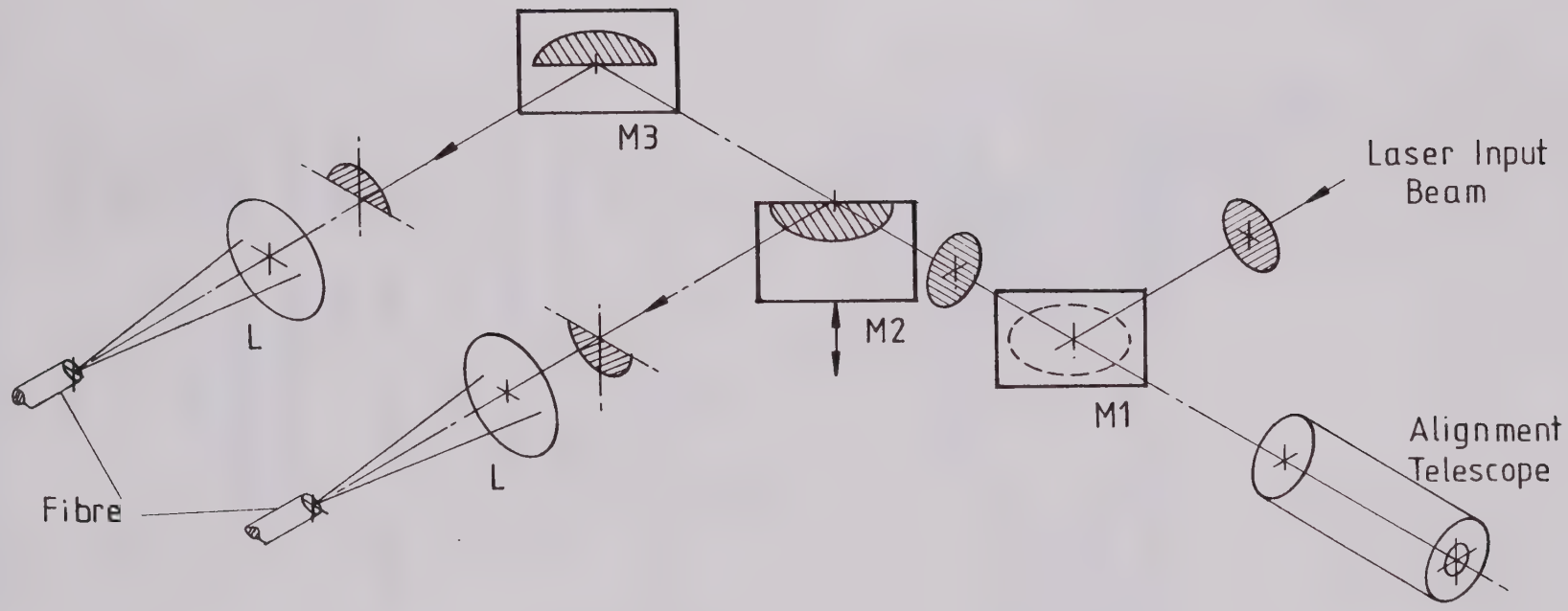

Fig. 5.2B SCHEMATIC OF 2-WAY ENERGY SHARE UNIT

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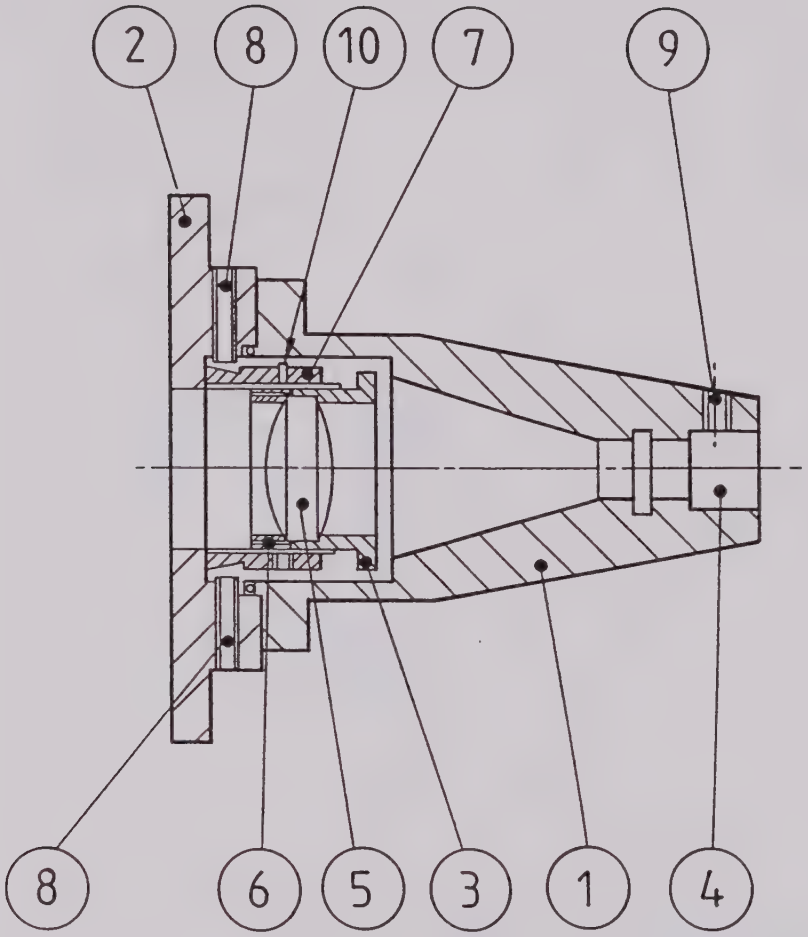

1. Module Body (rear)
2. Module Body (front)
3. Input Lens Mount
4. Fibre Input Ferrule location
5. Input Lens
6. Lens Retaining Ring
7. Lens Centering Mount
8. Adjusting Screws
9. Fibre Locating Set-Screw
10. Locking Screw

FIG. 5.2C SCHEMATIC OF INPUT MODULE

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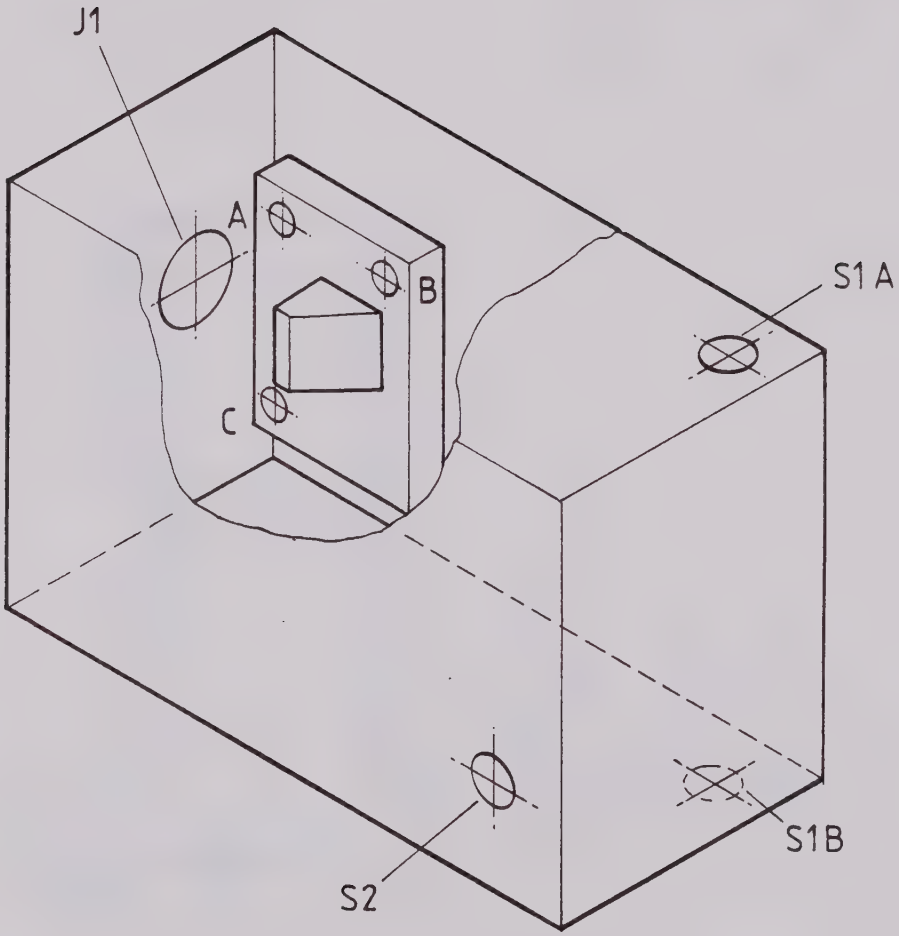
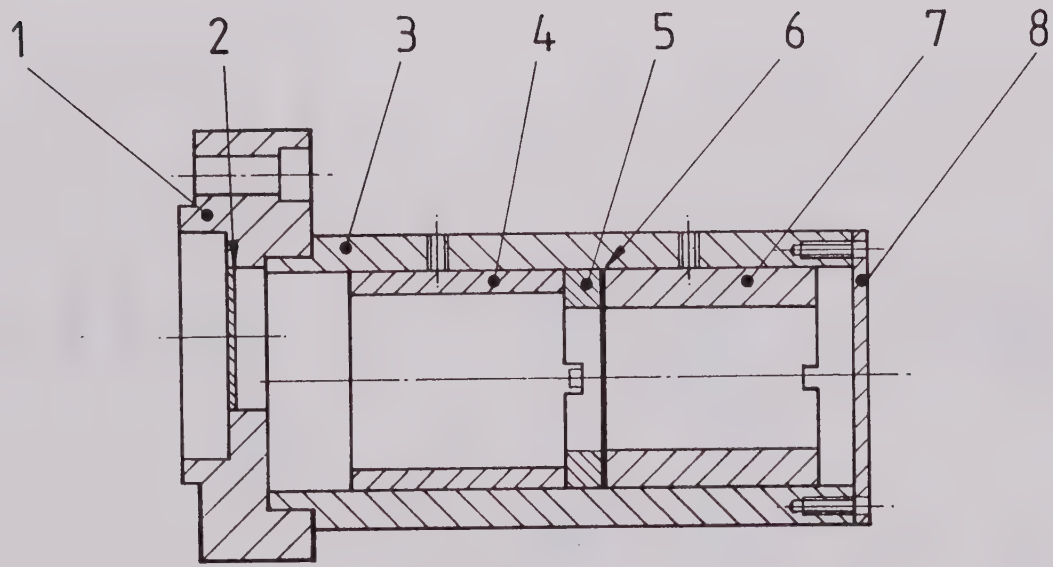


S1 A, S1B, S2 - Adjustment Screws (SMM)

A , B , C - Fixing Screws (Energy Share Modules)

J1 - Alignment Jig Port (FESM)

Fig. 5.2D SCHEMATIC OF ENERGY SHARE UNIT



1. Mounting Flange
2. Cover Slide
3. Tube
4. Setting Ring
5. Film Clamp
6. Kapton Film
7. Film Holder
8. Protective Cap

Fig. 5.2E KAPTON FILM MODULE

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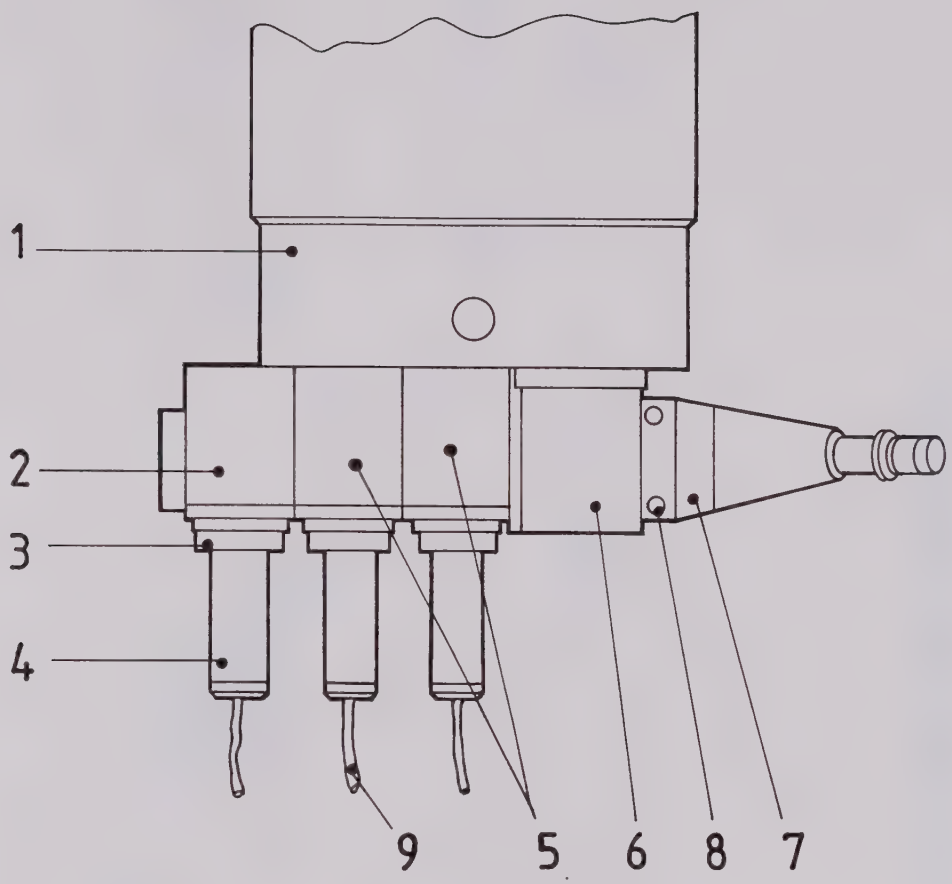

1. Laser.
2. Fixed Energy Share Module.
3. Front Input Module.
4. Rear Input Module.
5. Time Share Module.
6. Steering Mirror Module.
7. Alignment Telescope.
8. Telescope Lens Centering Screws.
9. Fibres.

FIG. 5.2F DIAGRAM OF TIME SHARE UNIT

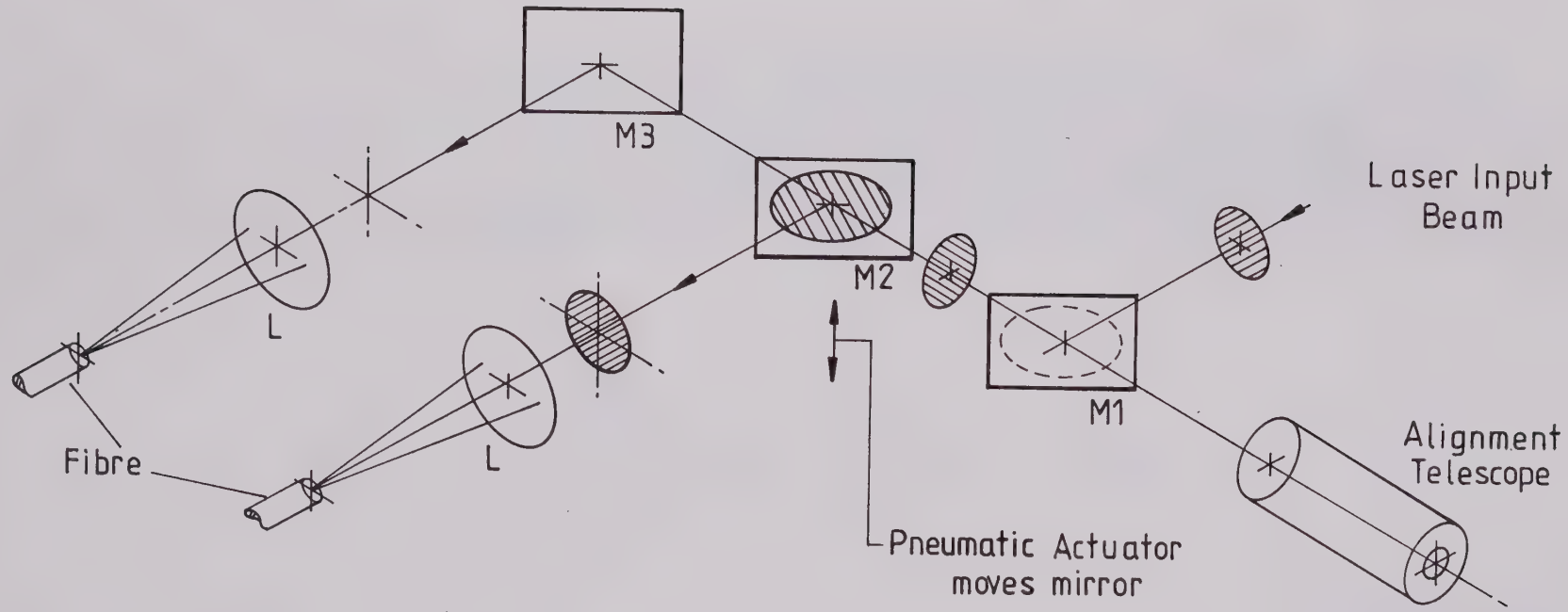

FIG. 5.2G. SCHEMATIC OF 2-WAY TIME SHARE UNIT

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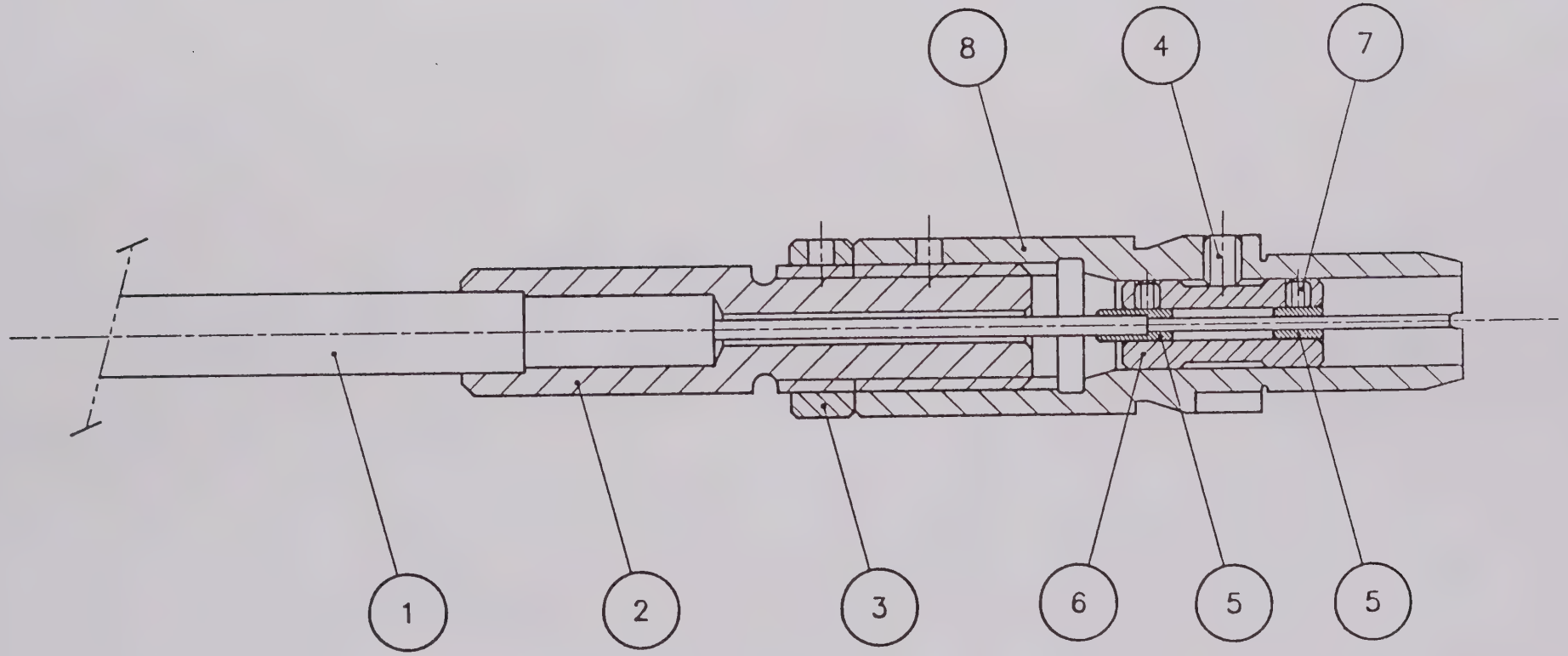

1. CONDUIT
2. CONDUIT TERMINATOR
3. LOCKING COLLAR
4. SET SCREW
5. FIBRE BEADS
6. SLEEVE
7. SET SCREW
8. OUTER SLEEVE

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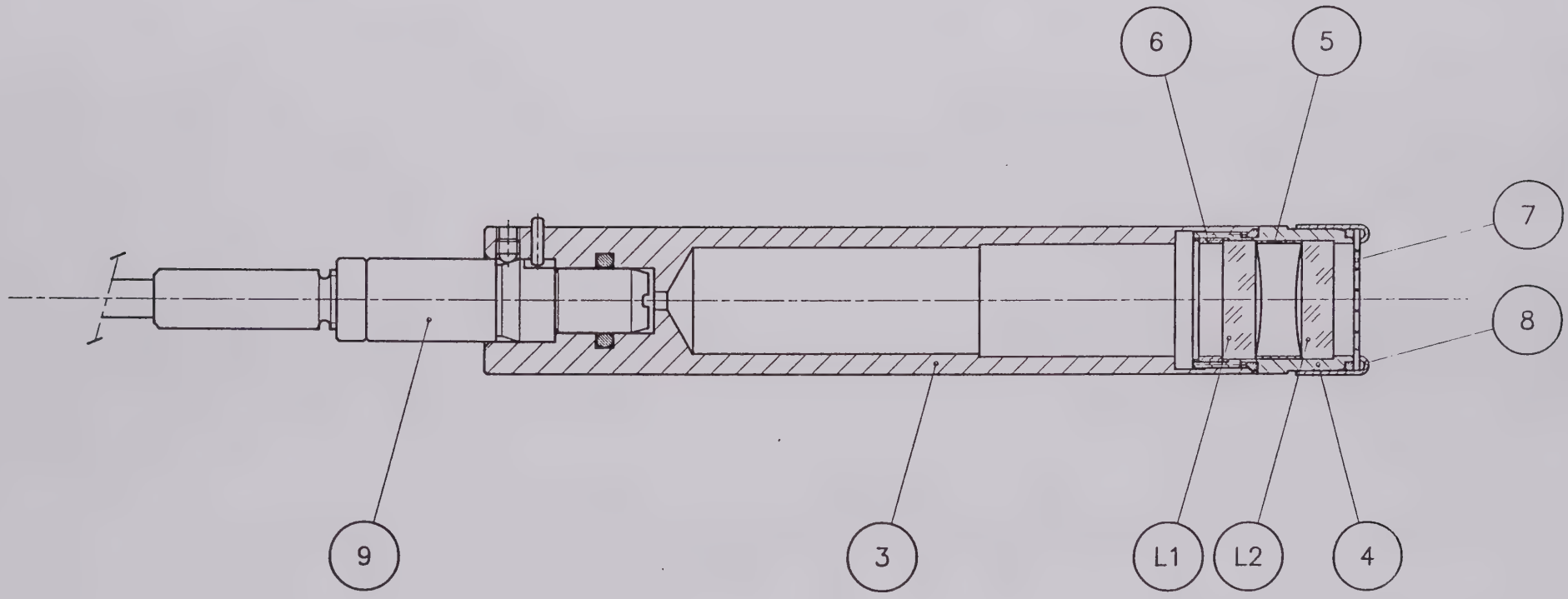
FIG. 5.3

FIBRE ASSEMBLY



L1. RECOLLIMATING LENS
L2. FOCUS LENS
3. FOCUSSING HEAD TUBE
4. LENS CELL
5. SPACER
6. LOCK RING
7. PROTECTION SLIDE
8. SPRING CLIP
9. FIBRE ASSEMBLY

FIG. 5.4

FOCUSSING HEAD ASSEMBLY

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SECTION 6

OPERATING INSTRUCTIONS

6.1. Precautions

6.1.1. Introduction
6.1.2. Precautions against misalignment
6.1.3. Precautions against physical damage
6.1.4. Laser-safety precautions
6.1.5. Time Share Interlocking

6.2. Operating instructions

6.2.1. Introduction
6.2.2. Start procedure
6.2.3. Stop procedure

6. OPERATING INSTRUCTIONS

6.1 Precautions

6.1.1 Introduction

The MULTIFLEX fibre beam-delivery system is a reliable system. However, it must not be forgotten that continued performance relies on a small diameter focussed beam remaining correctly aligned onto a fibre core. Moreover, the intensity on the input face of the fibre is essentially the same as the intensity on the workpiece situated at the output of a MULTIFLEX system, where it is expected to melt if not vaporise material.

In order therefore to assure reliable operation it is VITAL not to disturb the alignment between the laser beam and the fibres; and it is VITAL not to allow contamination to enter the optics, particularly the energy-share unit.

It is also important not to break the fibres through mechanical abuse.

The precautions which follow are intended to highlight those actions which, through thoughtlessness, ignorance or carelessness, could prejudice the continued and safe operation of this equipment.

WARNING (1)

It is VITAL that if the alignment is disturbed, for whatever reason, then the equipment is not operated again until an alignment check has been carried out by an authorised TRAINED person.

WARNING (2)

If contamination does get into any of the optics, the equipment must not be operated again until the optics have been inspected and cleaned as necessary by an authorised TRAINED person.

WARNING (3)

If fibre assemblies or focussing heads are known to have been subjected to incidents likely to cause damage, the affected parts of the equipment must not be operated again before checks have been carried out to determine whether the suspect parts are damaged.

6.1.2 Precautions against misalignment

1) No part specified below should be adjusted, released, or removed.

2) It is NOT safe to assume that if a part is removed and subsequently replaced (WHATEVER the precautions that have been taken) that the alignment will not be affected.

3) Do not assume that if adjusters are moved and then returned to the original position, that the alignment will be unaffected.

4) Any interference with the items specified below, must be followed by an alignment check by a TRAINED person.

CRITICAL items are as follows:

1. Laser output mirror

   - mirror; mirror holder

2. Beam-expanding telescope

   - fixing screws; adjusting knobs; lens carriage clamps; individual lens holders

3. Clamp plate pinch-bolt; fixing screw between laser and second energy share module

4. Steering mirror mount

   - adjusting screws (3)

5. Alignment telescope

   - mounting screws (4); lens travel clamp screw; lens centering screws(4); eyepiece clamp

6. Variable energy share module/fixed energy share module

   - mirror; fixing screws(3)

7. Rear input module body

   - lens adjusting screws(4); body securing screws(4)

8. Fibre assembly

   - securing screws(2)

6.1.3 Precautions against physical damage

1. Fibre assemblies and focussing heads should not be subjected to unreasonable mechanical forces -

   - tension, torsion (ie twist), impact, shear or severe compression.

   DO NOT drop, hammer or knock focussing heads. HANDLE WITH CARE.

2. No part of the fibre beam delivery equipment must be operated at temperatures in excess of 50°C. Observe the procedure outlined in Section 4.3.1.

3. No part of the equipment should be subjected to excessive damp or humidity.

4. DO NOT release the socket-head grub screws (2) which secure the conduit output termination into the output ferrule of the fibre-assembly. This will cause the fibre to BREAK.

5. DO NOT subject the fibre assemblies to bends with less than 20cm radius of curvature under any circumstances.

   Try to make the radius of bends as large as possible; also try to make the rate of change of curvature as low as possible.

6. Provide adequate support for the fibre assembly but clamps should not be so tight as to prevent the fibre from moving longitudinally or rotating so as to minimise axial or torsional stress.

7. Ensure that a cover-slide is ALWAYS present in the focussing head. Check the contamination level of the cover-slide regularly. If in doubt change the slide!. Keep records as to machine useage and previous cover-slide life so that inspection and probably change-dates can be predicted in advance.

8. Clean focussing heads as much as is practicable before changing cover-slides, to prevent dust entering the focussing head when the slide is removed.

   If the cover slide is absent for more than a few seconds, tape over the end of the focussing head to prevent ingress of dust and insects. Remember to DISABLE the laser FIRST.

9. Finally, physical damage can be caused to the fibres inside the distributor if the alignment of the laser beam to the fibre is impaired.

   Section 6.1.2. outlined possible causes of mechanical misalignment.

6.1.4 Laser-safety precautions

1. Ideally the workpiece and operating focussing heads should be mounted inside a Class I work enclosure.

2. Ensure that focussing heads are firmly secured in position.

3. Check the fibre assemblies regularly for signs of physical damage, including signs of over-heating. Inspection should be restricted to visual inspection; do NOT dismantle any equipment unnecessarily.

4. If possible, point the focussing heads downwards rather than horizontally or upwards.

   Mount the focussing heads so that the beam path is terminated, ie if there is no workpiece present then the beam hits a metal plate for instance rather than propagating into open space.

5. Ensure that CDRH Maintenance checks are carried out regularly - they protect you.

6. Be aware that reflective metal parts may well reflect a significant proportion of incident light; take appropriate precautions.

7. ALWAYS wear laser safety goggles for service/maintenance when the laser is operated with covers removed from either the laser or the work chamber.

8. ALWAYS wear laser safety-goggles if parts are processed other than in an interlocked Class I work-enclosure.

9. ALWAYS disable the laser (remove the ENABLE key) when carrying out any maintenance or service operation, especially changing cover-slides.

6.1.5 Time Share Interlocking

If the laser system and an associated work enclosure are to operate to Class 1 Standards then the work enclosure door must have an interlock which inhibits firing of the laser when the door is open. This would normally connect in series with the laser shutter. A time share system can be treated in this way only if all fibres are in place in a single enclosure. If the system is used to laser process in a number of separate workstations then each must be interlocked separately. However normally it is desirable that the interlock should operate so that if the laser is not switched into a particular enclosure then opening the enclosure door will not close the shutter. This will allow processing to continue in another enclosure while ensuring that the first is safely interlocked. The laser output will then only be stopped if the door of the working enclosure is opened. In order to achieve this arrangement it is necessary that the individual time share modules are fitted with switches of an approved type (positive break) which can be used to override the individual interlocks.

Each TSM module is fitted with two switches, one is broken whenever the mirror is not in the fully out state, the other is broken whenever the mirror is not in the fully in state. When the mirror of a TSM is "in" it fully intercepts the laser beam which is then transmitted through the fibre attached to that TSM. The enclosure served by that fibre should be interlocked such that opening the door will close the laser shutter unless the TSM is in the fully "out" position. If a system is fitted only with TSM modules then the interlocking can be accomplished simply by connecting the "out" limit switch of each TSM in parallel with the associated enclosure door switch. However when systems are fitted with VESM and/or FESM units in addition to TSM modules then the interlocking becomes more complex. In such a case the interlocking of the individual TSM's and their associated enclosures is treated exactly as before, but the VESM/FESM units and their fibres are a passive unit which receives laser power only when all the TSM's are switched into the "out" position. This means that an enclosure associated with the VESM/FESM can have its interlock overridden whenever any of the TSM's in the "in" position and blocks the beam. In order to provide the interconnecting circuitry for the interlock an interface unit is supplied where necessary which connects up all the TSM switches (up to a maximum of three TSM's) and provides a customer interlock connection for each possible work enclosure. Many possible interlock combinations are possible depending on the type of equipment supplied and how it is used. Interlock circuits/interfaces will therefore vary from unit to unit. Necessary details of any such equipment fitted to this system will be found in section 10. (appendix)

6.2 Operating instructions

This description applies to JK700 series lasers. Refer to section 10 for other lasers.

6.2.1 Introduction

BEFORE attempting to operate a MULTIFLEX system, make quite sure that:

- You have read and understood sections 1 to 7 of this manual.
- You have read, understood and implemented the precautions in section 6.1 of this manual.
- The complete equipment, including the laser, has been installed by an authorised TRAINED person and is in an operable state.
- You have read, understood, and are fully conversant with the laser operating manual.
- Laser safety-checks have been carried out regularly as specified in section 7.2.

6.2.2 Start procedure (JK700 series)

A. Manual Operation

If the laser is to be operated under manual control:

- Prepare the laser for operation (mains power; cooling water; etc)
- Operate the ENABLE key-swtich
- Press the COOLER on-button
- Press the POWER on-button

Wait for 'emission' and 'ready' indicators to light up.

- Set the operating parameters (HEIGHT, WIDTH, RATE, SHAPE) to desired values. N.B. If this is the first time of operation at these values, set the HEIGHT demand to a low value.
- Ensure that the SHUTTER is closed.
- Put on laser goggles for all but Class 1 systems.
- Press LOCAL to initiate laser action; this sets the laser pulsing and an output energy value should register on the energy monitor display.
- Modify the HEIGHT demand as necessary to achieve the desired output energy.
- To achieve laser emission, operate the shutter controls as required.

The laser is now prepared for manual operation, using either the shutter controls on the control panel, or the remote-control box, or external electrical control of the shutter.

B. Remote Control (CNC, PLC)

Proceed as for Manual Operation; then:

- Prepare the CNC/PLC for operation; insert the desired laser parameters into the CNC/PLC programme.
- Put on laser goggles for all but Class 1 systems.
- Press REMOTE to enable the laser for remote-control.

The equipment is now ready for operation, assuming that all parts-handling equipment is ready for action.

To initiate laser emission, run the PLC/CNC programme.

6.2.3 Stop procedure (Close-down)

A. Manual Operation

1. Close the laser shutter.
2. Press LASER OFF, then SYSTEM OFF.
3. If activities are completed, turn the ENABLE key to the off-position and withdraw the key. Then switch off mains power and cooling water supplies.

B. Remote Control

1. Stop the CNC/PLC programme.
2. Ensure the laser shutter is closed.
3. Press LASER OFF; then SYSTEM OFF.
4. If activities are completed, turn the ENABLE key to the off-position and withdraw the key. Then switch off mains power and cooling water supplies.

SECTION 7

ROUTINE MAINTENANCE

7.1. Routine Maintenance

7.1.1. Inspection of Coverslide (in position)
7.1.2. Cover-Slide Removal
7.1.3. Cleaning Cover-Slides
7.1.4. Fitting Cover-Slides

7.2. Laser-Safety Maintenance

7.2.1. BS/CDRH Compliance Checks
7.2.2. General Checks

7. ROUTINE MAINTENANCE

7.1 Routine maintenance

The only consumable item in the MULTIFLEX system and the item which therefore requires appropriate inspection and maintenance (ie changing) at appropriate intervals, is the cover-slide in each focussing head.

7.1.1 Inspection of cover slide (in position)

1. Ensure that the laser is disabled; remove the ENABLE key.

2. To determine the level of contamination on a cover-slide, treat it like a mirror. Look into the slide at the reflection of a piece of brightly-lit white paper. A lamp and a mirror may help this procedure!

If there is any doubt, change the slide since, if it is used beyond its useful life, then it will crack. This may have an adverse effect on weld-quality and will certainly expose the underlying optics to the risk of contamination and optical damage.

7.1.2 Cover-slide removal

1. It is important to remove excess dust from the area around the cover-slide, preferably with a vacuum cleaner, to prevent the ingress of dust when the slide is removed.

2. Unscrew the knurled cover-slide retaining ring and remove the slide. If this is difficult, use a piece of adhesive tape. DO NOT bang the focussing head!

3. Again, if dust is present, do NOT blow it; suck it out with a vacuum-cleaner.

4. Put the retaining-ring in a clean place; do not get dirt into the fine thread.

7.1.3 Cleaning cover-slides

1. ALL optics through which the laser beam passes, MUST be absolutely clean. Otherwise energy will be absorbed by the dirt on the surface, and this will result in damage to the surface. Consequently, the cover-slides MUST be cleaned before fitting, as follows.

2. Work on a clean surface with clean hands.

3. First, with a rubber-bulb puffer, remove any obvious dust particles from the faces of the cover-slide.

4. Then wipe the faces of the cover-slide with a pad of lens-tissue, damped with solvent as follows.

5. Carefully fold a lens-tissue into a pad which is just slightly narrower than the cover-slide. Then the cover-slide can be wiped across the full-width with a single-stroke. Multiple passes with a narrow pad leave streaks.

When folding the tissue, always hold it at the edges so that the central area which comes into contact with the slide, has not been touched, otherwise finger-grease will be transferred to the slide.

6. Damp the tissue by holding the pad horizontal and tipping the solvent (PROPAN-1-OL / IPA / ISOPROPANOL preferred) onto the pad. DO NOT put the pad on top of the bottle and then invert the bottle; this saturates the pad but, worse still, if the pad is contaminated then the entire contents of the bottle become contaminated.

7. Hold the slide by the edge with your finger-tips (or special tweezers if you have them) and wipe the slide ONCE using a straight movement, before THROWING AWAY the pad.

8. If necessary, make a new pad and repeat the process until, when viewed as a mirror (Section 7.1.1.) the slide looks clean.

7.1.4 Fitting cover-slides

1. The slide must be clean and it must stay clean. During the insertion process it must be held so that NO finger-marks are put on the polished surfaces of the cover-slide.

2. The method of insertion depends on the inclination of the focussing head to the vertical. A little practice will indicate the best method.

3. If the focussing head is pointing downwards then the best method is to place the slide on the retaining ring and then offer them both up together into the focussing head.

4. If the focussing head is pointing upwards (NOT good practice) then the slide should be inserted first. The best policy in these circumstances is to incline the slide at an angle of 45° to the vertical and lower it into the focussing head, attempting to place the lower edge onto the seating. Then release the slide and it should drop into place. If it does not, do NOT press it or poke at it. Remove it with a piece of adhesive tape, clean it and try again. This should convince you that upward-pointing focussing heads are not advisable!

5. Remember to secure the slide retaining ring - not too tight nor too loose.

7.2 Laser-safety maintenance

7.2.1 BS/CDRH compliance checks

The only safety features that need to be fitted to make the MULTIFLEX system comply with national and international safety standards, are safety labels. Note that there is a separate laser-safety maintenance schedule for the laser (refer to the LASER manual).

Accordingly you must check, EVERY week, that the specified labels are in position, securely attached. Contact Lumonics if spare labels are required. Refer to Sections 3.4. and 3.5. for details.

7.2.2 General checks

Every day, inspect the fibre-assemblies for signs of damage, overheating, loose joints, loose screws, etc. - anything that looks like early-warning of a problem. Damaged fibres should be taken out of service and replaced at the first opportunity.

If abnormal welds start to appear from one fibre, investigate why!

If weld-energy requirements on one particular fibre start to increase, investigate why.

This could be an early sign of a fibre failure, or a problem with output optics.

If in doubt, do not use that fibre again.

NOTE It is vital to keep process-records relating to laser and process parameters so that abnormalities can be detected.

SECTION 8

SERVICE PROCEDURES: - INSTALLATION, COMMISSIONING, ALIGNMENT

8.1 Introduction
8.2 Laser
8.3 Laser beam-expanding telescope
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- 8.4.1 Introduction
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- 8.4.6 Alignment of fibre assembly (FESM)
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- 8.4.8 Alignment of fibre assembly (VESM)
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- 8.4.10 Alignment of fibre-assembly (TSM)

8.5 Adjustment of energy-balance between fibres.

CDRH WARNING

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein, may result in hazardous (laser) radiation exposure.

SAFETY WARNING

The alignment telescope is intended to facilitate alignment of the equipment prior to operation. It is not intended that the telescope should be viewed through with the Nd/YAG laser in operation. However, in case the telescope is so used, a safety viewing filter is fitted.

Before using the alignment telescope with the laser in operation, always check that the filter is present and in good condition. DO NOT remove the filter other than to service it and, as soon as the filter is removed, tie a warning label onto the telescope, indicating that the telescope is unsafe to use.

WARNING

It is VITAL to wear laser safety goggles of adequate optical density when performing service operations with the laser pulsing.

8. SERVICE PROCEDURES: - INSTALLATION, COMMISSIONING, ALIGNMENT

8.1 Introduction

This section of the manual describes SERVICE procedures. It is included for the benefit of Lumonics engineers and customer's engineers who have received training in MULTIFLEX servicing.

The presence of this section in this manual is NOT an invitation to untrained personnel to attempt to service this equipment. Such acts will void Lumonics warranty.

This section gives comprehensive details not only on alignment but also installation and commissioning information, including appropriate preparation of the laser.

8.2 Laser

A range of fibre diameters is available within the MULTIFLEX product range. It is important that the fibre size and laser beam quality (diameter and divergence) are compatible with each other. Check appendix (Section 10) for details of equipment supplied. Do not assume that a different fibre diameter may be fitted without some adjustments to the laser being necessary. If in doubt, check with Lumonics.

8.3 Laser beam-expanding telescope (BET)

In addition to the restriction in [beam diameter x beam divergence] product, the laser beam must be collimated at the exit port of the laser, with a beam diameter of approximately d mm. (see Section 10). For this requirement to be satisfied the BET must be set to the correct magnification, and the lens separations adjusted for collimated output. The procedure described below relates to the JK700 series lasers. For other types of laser, a somewhat different technique is involved. In such cases refer to section 10 for guidance.

On JK700 series lasers the BET incorporates three lenses - referred to here as 'input', 'centre' and 'output' lenses (figure 8.3) In broad terms the position of the centre lens determines the magnification and the position of the output lens is adjusted to achieve collimation of the output beam.

When a JK700 series laser is used for materials processing investigations there is a need to adjust the lens positions on a regular basis to achieve optimum processing performance. Accordingly standard lasers are provided with external controls.

However, in the case of lasers fitted with MULTIFLEX products, the sole purpose of the BET is to preset the laser beam to the MULTIFLEX module with acceptable values of beam diameter and beam divergence. Once these values are set then there is no need for subsequent adjustment; in short, the BET controls are required only for factory (service) setting.

Once these positions have been determined then they must not be changed. To ensure that the BET lens positions are not changed accidentally, carriage clamps are fitted onto the lens support bars inside the BET.

The purpose of the following procedure is to set the lenses to approximately the correct positions - then further to adjust the lens positions to achieve a collimated beam at the laser front plate.

1. With the laser power supply switched off for safety:

   - Remove the laser head outer lid
   - Remove the BET housing lid (4 screws)
   - Release the screws that fix the lens carriage clamps in position on the lens support bars in the BET housing. The lens positions can now be varied by means of the adjuster knobs on the ends of the lead screws, outside the BET housing.

2. Set the centre lens approximately x mm from the small input BET lens, and set the output lens approximately y mm from the input lens; i.e. centre and output lenses approximately z mm apart. See appendix (Section 10) for values of x, y and z.

3. Replace the BET housing lid and secure with fixing screws.

4. The next step is to check the diameter and collimation of the pulsed Nd/YAG beam at the laser front plate, by firing single laser shots onto burn paper and measuring the burn diameters.

   For this procedure it is necessary to remove the complete MULTIFLEX energy-share assembly from the laser, if it is already fitted, as follows.

   Remove the screw securing the second (VESM or FESM) module to the laser front plate. This is accessible below and behind the front plate.

   Release the clamp screw which secures the spigot of the beam-steering module in the clamp boss on the laser front-plate and carefully withdraw the entire assembly from the boss. Ideally no fibre assemblies should be fitted when this operation is carried out.

5. Now the laser is going to be fired. Refer to the laser handbook before proceeding. Before switching the laser on you should be fully familiar with the laser handbook taking particular care to read the sections on Safety and Operation. Before firing the laser you should ensure that everyone in the vicinity is also familiar with the safety requirements. In paticular, you should be wearing safety goggles which are designed to protect against exposure to a Class 4 laser of 1060nm wavelength.

   Prepare the laser for operation; refer to the laser handbook. Remember to turn on the mains tap-water supply.

Ensure the shutter is closed then set the laser operating at the required setting parameters (see section 10)

6. Take a new piece of burnpaper, superimpose a protective glass slide (from your maintenance kit) and take single shot burn patterns at the clamp boss and also at locations 100mm and 200mm beyond the clamp boss (i.e. outside the laser).

7. Measure the diameters of the burn patterns accurately. Ideally they will be all of exactly the same diameter (within 0.3mm) and within the range d1-d2. See appendix (Section 10) for ratios of d1 and d2 for the system.

8. If the burn diameters get smaller with increasing distance from the laser then rotate the lens position knob K3 (figure 8.3) nearest the outer wall of the laser head by one half-turn anti-clockwise: Conversely if beam diameter increases with distance from the laser then turn K3 by one half-turn clockwise.

Now repeat steps 6 and 7

9. If the difference in burn diameters is less than it was at step 7, repeat steps (8), (6) and (7) until the overall diference in burn diameters is acceptably small (less than 0.25mm).

10. If the burn diameters achieved at 'step 9' lie outside the range d1-d2 then rotate the lens position knob K2 (remote from the outer wall of the laser head) as follows:

- one half-turn clockwise if the beam diameter is less than d1.
- one half-turn anti-clockwise if the beam diameter is greater than d2.

11. Adjustment of K2 inevitably upsets the equality of beam diameter with distance and further adjustment of K3 will now be necessary.

Steps 6, 7, 8 and 9 must therefore be repeated until the required size and collimation is achieved. Normally it is was necessary to rotate knob K3 clockwise to achieve collimation of the output beam.

12. When the required output beam characteristics have been achieved.

- Remove the BET housing lid.
- Position the lens carriage clamps (2 each for the centre and output lenses) tightly against the appropriate lens carrier plate taking care not to change the axial position of the lens plate, and secure them in place so as to prevent axial movement of the carrier plate.
- If there is doubt repeat steps (6) and (7)
- Switch off the laser (LASER OFF)
- Replace and secure the BET housing lid
- Replace and secure the laser head outer lid.

NOTE It is VITAL that no part of the BET assembly is touched beyond this stage, other than for procedures which will include a complete realignment of the MULTIFLEX unit. If this warning is ignored then there is a strong probability of damaging the MULTIFLEX fibres.

8.4 Alignment of energy/time share distributor unit

8.4.1 Introduction

As explained in section 5, components in the MULTIFLEX energy/time share modules are provided with adjustments in order to facilitate correct alignment of the unit to the laser beam. When the unit is correctly aligned the laser beam axis is coincident with the design optical axis of the unit, so that:-

1) After reflection off the beam steering mirrors the beams (partial beams in the case of VESM's) are focussed onto the centres of the corresponding fibres.

2) The cone of the focussed beam enters the fibre symmetrically along its axis. (In the case of VESM's this condition is set when the mirror is intercepting 100% of the beam).

The procedure can be broken down into a number of sequential operations:

1. Adjustment of beam-steering mirror (8.4.2)
2. Adjustment of fixed energy share module (8.4.3)
3. Location of focal plane of fibre input lens (8.4.4)
4. Setting up the alignment telescope (8.4.5)
5. Alignment of fibre (fixed energy share module (8.4.6)
6. Adjustment of variable energy share modules (VESM) (8.4.7)
7. Alignment of fibre assemblies (VESM) (8.4.8)
8. Adjustment of time share modules (TSM) (8.4.9)
9. Alignment of fibre assemblies (TSM) (8.4.10)

All nine steps are only required in the case of a combined time and energy share unit containing both TSM's and VESM's. If only TSM's or VESM's are fitted to your unit sections 6 and 7 or 8 and 9 are omitted as appropriate.

In the following sections, the procedure is described for building up and aligning a system from beginning to end.

It is assumed that the basic unit has been assembled, with the steering mirror module (SMM) fixed to the appropriate number of time share modules (TSM) and/or variable energy-share modules (VESM), with fixed energy-share modules (FESM) on the end of the stack remote from the SMM (figure 5.2A)

It is further assumed that, at this stage:

- None of the TSM's, VESM's or FESM have slides or mirrors fitted.
- No fibre assemblies are fitted.
- The steering mirror is fitted in its mount and the assembly is fitted in the SMM, secured in place by the alignment telescope assembly.

- The steering mirror is clean (if in doubt, clean it).
- The alignment telescope has been checked to confirm that the green laser safety filter is present and in good condition, in the objective lens cell in the alignment telescope.

If any of the items detailed above, which are assumed to be absent, are in fact present then, they shoud be carefully removed, fitted with protective covering (e.g. in a plastic bag if possible) and stored so as to keep them absolutely clean and safe from damage.

8.4.2 Alignment of beam-steering mirror

1. Secure the clamp boss to the front plate of the laser with the clamp screw at the bottom right when looking at the front of the laser.

2. Offer the spigot (complete with O-ring) of the SSM into the clamp boss so that the unit is orientated as shown in figure 8.3 so that the VESM/TSM units lie to the left of the SSM (seen from the front of the laser) with the top of the composite assembly horizontal; secure the clamp screw in the boss.

3. In order to fix the energy share unit more rigidly to the laser front plate, there is provision for screws to be fixed through the second and third modules into the laser front plate.

   Locate the screw holes and secure with appropriate screws.

4. It is assumed that the steering mirror in the SMM is absolutely clean. If there is any doubt remove the mirror assembly and inspect/clean; and replace (Section 9). Do it now rather than later. If you do make sure the screws securing SMM mirror assembly and also the alignment telescope are tight. This is also an oportune time to check the presence/state of the safety filter in the alignment telescope.

   The purpose of this section is to adjust the steering mirror so that when the laser is fired, the reflected beam travels along the designed optical axis through the VESM's and FESM, defined by port J1 (figure 5.2D) in the end of the FESM.

5. Remove the cover plate from J fit the alignment jig in the port and secure.

6. Now prepare the laser for operation; and wear goggles suitable for a 1060nm Class 4 (IV) laser. Ensure the process shutter is closed and set the laser for operation. (see section 8.3, step 5).

   Place a piece of burn paper with a superimposed protective slide adjacent to the alignment jig and fire a single-shot. Inspect the burn for concentrating with the shadow of the alignment jig.

7. Adjust screws S1A, S1B to centre the beam on the jig in the vertical direction; and screw S2, for the horizontal direction (section 5.2D).

Remember that S1A, S1B are opposed screws, so one screw must be partially unscrewed before the other screw can effect a change of tilt of the steering mirror.

Aim to achieve equal burn quadrants; then secure S1A, S1B and S2 and take a final burn pattern to check.

8. Switch off the laser, remove the alignment jig and replace cover plate C and secure.

8.4.3 Adjustment of fixed energy-share module (FESM)

The aim of this adjustment is to ensure that the reflected beam off the fixed energy-share mirror, is coaxial in position and direction, with the axis of the fibre input module. To ensure this, an alignment tube is provided which can accomodate two alignment jigs - one at each end. The alignment tube is fitted onto the FESM, in place of the front module body (figure 5.2C).

To align the reflected beam with the axis defined by the alignment jigs, the FESM mirror mount can be tilted using a combination together with angular adjustment; and the position of the rear module body can be adjusted laterally.

The procedure is as follows:

1. Remove the top cover plate and gasket from the FESM.

2. Take the FESM mirror from its protective wrapping and inspect for integrity and cleanliness of the mirror surface. Clean the mirror surface if necessary.

3. Orientate the mirror mount so that hole C (figure 5.2D) is at the bottom of the mount. Insert screw C in the mount with a wave-washer and large flat washer under the screw head. Carefully lower the assembly through the aperture in the top of the FESM and secure screw C in its fixing hole, using an Allen key through the corresponding access hole in the front of the FESM. Partially tighten the screw so that the mirror assembly can be moved laterally when pushed.

   Next fit screws A and B (figure 5.2D) in the FESM baseplate, with a wave washer under the head of screw A, and, in the case of screw B, a wave washer and a large flat washer under the screw head, and a 2mm thick shim between the mirror baseplate and the FESM body. Access these screws through the top of the FESM; tighten using a ballended Allen key.

4. Now disassemble the FESM input module as follows

   - Unscrew the rear module body (figure 5.2C) from the front module body.
   - Remove the complete input lens assembly.
   - Unscrew the front module body from the FESM.

   Store the components in a safe clean place, ideally in plastic bags.

5. Secure the alignment jigs provided, in the ends of the alignment tube; with the spokes of the jigs inclined at 45° to each other.

6. The next step is to adjust the position of the FESM mirror mount and the front module body so that the laser beam is centred on both alignment jigs, as far as possible. In order to check the alignment, it is necessary to fire the laser.

7. Prepare the laser for manual operation (section 6.2.2). Wear safety goggles. Place a piece of burn-paper with superimposed protective cover glass adjacent to the outer end of the alignment tube; then take a single-shot burn pattern and examine for concentricity of the burn with the 2 alignment jigs. It may be necessary to remove the jig at the outer end of the tube and take a second burn-pattern, to facilitate interpretation.

8. Centering errors must then be corrected by adjustment of the lateral position of the front module body and the tilt of the FESM mirror mount.

   To alter the lateral position of the front module body, slacken the 4 fixing screws, reposition the body and resecure.

   There are two methods for adjusting the tilt of the FESM mirror mount. The mirror baseplate is secured in the FESM by screws A, B and C (figure 5.2D). Screw A passes through a close-fitting hole in the baseplate; screws B and C, through oversize holes. The base plate can therefore be rotated in its own plane about screw A which acts as a pivot.

   The second method of tilting the mirror mount is to fit one or more pieces of shim (thin U-shaped metal washers) between the mirror baseplate and the FESM body at Screw B. Shims of various thicknesses are included in the accessory kit provided with your MULTIFLEX unit.

NOTE

A. Lateral adjustment of the front module body will move both jigs laterally by an equal distance. This adjustment is therefore most useful where the shadows of the two jigs on the burn pattern, are mutually concentric, but not concentric with the burn.

B. Rotation of the mirror base plate about screw A will move the reflected beam in a <u>vertical</u> arc. This adjustment will therefore be most beneficial when there is a vertical error in the concentricity of the shadows of the jigs.

C. Conversely, fitting shim under the mirror base plate at Screw B will move the reflected beam in a <u>horizontal</u> arc. This adjustment will therefore be used to correct horizontal errors in the concentricity of the alignment-jig shadows.

Note that since the shim provides angular adjustment in steps, it will not be possible to achieve perfect alignment. However my making use of the range of shim thicknesses provided, the residual error can be minimised.

9. When acceptable alignment has been achieved tighten the three screws (A, B, C) to secure the mirror base plate in position and take a further burn pattern to confirm the alignment.

10. Switch off the laser (section 6.2.3) and remove the alignment tube from the front module body of the FESM.

8.4.4 Location of focal plane of input lens (FESM)

In order to couple the laser beam into a fibre the beam is focussed to a small diameter by the preceding input lens. The distance between the lens and the fibre must be set to the correct value. Where the diameter of the focussed beam is minimum, to ensure the beam does not overfill the fibre.

To determine the position of minimum beam diameter (the 'beam waist') the laser beam is fired onto a thin sheet of brown plastic material (Kapton film) set progressively at different distances from the lens, as follows:

Refer to section 5.2 and figure 5.2E.

1. Remove the FESM input lens assembly from its protective wrapping; inspect it for cleanliness and clean it if necessary.

   Then fit the assembly in place in the FESM front module body using four screws. The lens unit should be visually central in the front module body.

2. Next, check that there is a clean cover-slide in the bottom of the Kapton film module (KFM); see figure 5.2E. If in doubt, release 2 fixing screws to release the slide.

3. Then secure the KFM to the FESM front module body (3 screws). During this process it is advisable to slacken two (adjacent) of the input lens centering screws to allow the lens to settle into its correct position. It is then essential to check that all 4 centering screws are tight.

4. Cut off a 23mm square piece of Kapton film from the length provided and secure it in under the clamp ring on the film holder. Trim off protruding film with a sharp blade.

5. Insert the film holder into the KFM with the clamp ring innermost, open-end outwards, so that the film holder is recessed inside the KFM.

   Secure the film holder in the KFM using the grubscrew provided, otherwise the holder will move during the following procedure.

The equipment is now ready to determine the location of the minimum diameter of the focussed beam generated by the input lens. This is achieved by firing single laser shots via the lens onto the film. The film holder is advanced forwards, towards the lens in 1mm steps between shots, from a known start-position. Since the film holder is located in the KFM in a hole which is laterally displaced from the optical axis of the lens, when the film holder is rotated between laser shots, the burns start to form a circle of separated spots on the film. Proceed as follows:

SAFETY CAUTION

The laser is about to be fired. The beam will burn a hole through the Kapton film and virtually all the energy will be transmitted through the hole. It is therefore ESSENTIAL to secure the protective cap in place on the end of the KFM before the laser is fired. The cap should always be fitted when the laser is fired at the film.

6. Secure the safety cap (2 screws) in position on the outer end of the KFM.

7. Prepare the laser for operation (section 6.2.2) as before. WEAR SAFETY GOGGLES.

8. Fire a single-shot onto the film.

9. Remove the cap, release the grub screw securing the film holder rotate the film holder by about 4mm CLOCKWISE at the periphery and push the film holder 1mm farther into the KFM. Check this measurement with a ruler; do not guess. Tighten the grubscrew that secures the film holder in place REPLACE the safety cap (2 screws).

10. Repeat steps 8 and 9 each nine times in turn.

11. Switch off the laser (section 6.2.3) remove the safety cap, and withdraw the film holder.

12. Measure the outer diameter of the burn marks rather than holes burnt through the film using, preferably, calibrated microscope. Always measure the same direction on each burn. Thus if the burns are elliptical, always measure say, the major axis of the burns. Remember that the film was rotated between shots, the film must be rotated between measurements to maintain a constant direction of measurement.

    Decide which is the smallest diameter burn. You may need to consider the diameters of the burns either side of your first choice, before confirming, the decision. Then decide what was the depth of insertion of the film holder in the KFM, corresponding to the smallest diameter burn. Think carefully; this is a crucial value. If you feel the optimum position lies between the distance corresponding to two adjacent burns then, set the holder to the mid-value. e.g. smallest burn diameter burns for insertion depths 27mm and 28mm; then assume 27.5mm to be the optimum value.

13. The end of the fibre, when fitted, will lie at a position equivalent to a depth of insertion of 24.5mm. The position of the focus lens must now be coarsely adjusted to bring the minimum beam diameter into the same plane as the fibre. Subtract 24.5mm from the depth of insertion determined in step 12. This is the amount by which the lens must be adjusted. If the depth of insertion is greater than 24.5 the lens is screwed out, if less it is screwed in.

14. Remove the KFM from the input module body.

15. Unscrew the threaded lens holder until it has moved, relative to the centering mount, by the required amount of adjustment. (Take a measurement between the rear of the lens holder flange and the centering mount to check.)

8.4.5 Setting up the alignment telescope

The next stage in the procedure is to fit a new piece of film in place at the optimum focal plane, fire the laser once to generate a reference burn mark; then, to align the alignment telescope to the the reference burn.

Proceed as follows.

1. Fit a new piece of Kapton film into the film holder (section 8.4.4, step 4).

2. Identify the 'setting-ring' in the accessory kit; it has the same diameter as the film holder.

3. Insert the ring into the KFM first, followed by the film holder (usual orientation). Push the film holder in with a ruler so that you can monitor the insertion depth . Push the film holder in exactly 24.5mm.

   Then secure the ring in place using the relevant grub-screw in the KFM.

   Check that the insertion depth of the film holder is optimum, when pressed against the setting ring. Then secure the film holder in place (1 grub screw).

4. Secure the KFM safety cap in place (2 screws).

5. Prepare the laser for operation (section 6.2.2); again. WEAR SAFETY GOGGLES.

6. Fire a single-shot onto the film. Switch off the laser (section 6.2.3).

7. Remove the safety cap from the KFM so that light can enter the film module. If the ambient light level is low, an auxiliary lamp may be required for the next procedure - setting up the alignment telescope.

IMPORTANT

8. The alignment telescope is about to be set up as a stable reference which will facilitate quick and easy exchange of fibres, should this prove necessary. It is important therefore, if it is to be a reliable credible reference that:

   - The clamp that secures the eyepiece rigidly in the eyepiece tube is tight.
   - That the eyepiece is rigidly fixed - since the eyepiece contains a reference graticule.

   Read section 5.2 again to familiarise yourself with the construction and principles of the alignment telescoope.

9. Ensure that the telescope eyepiece focus is adjusted so that the image of the graticule is sharp. Then remove the cover plate (2 screws) beneath the telescope, which gives access to the telescope focus adjustment. Release the exposed clamp-screw and adjust the axial position of the lens assembly (by translating the screw, to achieve sharp focus of the image of the burn pattern on the Kapton film, seen in the telescope eyepiece. It is essential that the eyepiece is not refocussed in this procedure so that the image of the graticule remains sharp. Thus, when this adjustment is completed then both the Kapton burnmark and the graticule can be seen in sharp focus simultaneously. Secure the lens assembly clamp-screw and replace and re-secure the cover plate.

10. The next step is to align the image of the graticule, seen in the telescope eyepiece, to the centre of the burn pattern image. This is achieved by lateral translation of the objective lens assembly in the telescope, using 4 centering screws (figure 5.2A). Note that the screws are arranged as two orthogonal diagonally-opposed pairs.

    To allow the lens holder to move, release all four screws. Then choose one and screw it in again whilst viewing the image of the graticule and the burn pattern in the telescope eyepiece. When the two images are as close as possible to being completely superimposed (centre of outer burn coincident with centre of graticule), stop.

    Then choose an adjacent screw from the other opposed pair and repeat the process; if this makes the images diverge rather than converge withdraw this screw again and screw in the opposite screw.

    Continue until the two images are perfectly concentric when this has been achieved, carefully screw in all four screws in turn so that

    - The burn and graticule images remain concentric.
    - All four screws are tight.

Now the information relating to the position of the laser beam focus, has been transferred from the Kapton film to the telescope graticule, PROVIDED that none of the following components was adjusted between making the reference burn on the film and adjusting the telescope viz

- Steering mirror assembly
- FESM mirror assembly
- FESM input module
- FESM input coupling lens
- KFM

Since all these components affect the position of the burn on the Kapton film.

After the telescope has been adjusted, then the KFM and film holder can be removed and the FESM input lens can be adjusted as required without affecting the telescope setting.

IMPORTANT

The alignment telescope can now be used to predict accurately the position (lateral and axial) of the beam waist (minimum beam diameter) produced by any input lens in any of the modules (VESM's or FESM) PROVIDED that the telescope is not subsequently altered in any respect viz

- telescope removed from SMM
- centering or axial adjustment of telescope lens assembly
- eyepiece clamp released

If <u>any</u> of these conditions has been violated then reliance on the telescope as an alignment aid will <u>not</u> be valid and damage to <u>all</u> the fibres is CERTAIN.

Therefore, IF IN DOUBT, REALIGN THE ENTIRE ASSEMBLY (i.e. section 8.4 complete).

11. Remove the KFM from the FESM and replace it in the accessory kit.

8.4.6 <u>Alignment of fibre assembly (FESM)</u>

The alignment telescope has just been aligned and it is now going to be used as a reference for fibre alignment. The KFM has just been removed from the FESM front module body, following the telescope alignment procedure.

The next step is to reassemble the rear module body (figure 5.2) then attach the fibre assembly (if detached) and finally, to adjust the fibre/input module alignment using the alignment telescope.

Proceed as follows:

1. If the fibre assembly has been detached from the rear module body, refit it and secure it with the single lock screw.

Otherwise it is assumed that the fibre assembly is already attached to the rear module body and there is good evidence that the fibre input face is clean and precautions have been taken to keep it clean (e.g. protective wrapping covers the open end of the housing). If there is any doubt the fibre assembly must be removed and the input face of the fibre inspected in fine detail and, if necessary, cleaned.

2. To see the image of the fibre input face in the telescope eyepiece, it is usually necessary to illuminate the fibre by shining a lamp into the output housing of the fibre. There is no need to remove the output housing for this process; indeed unnecessary removal is not advised.

3. Remount the rear module body on the front module body but do not secure it with fixing screws. Hold it in place by hand but ensure that it is square and pushed fully home onto its location.

   Check whether the image of the outline of the fibre face seen in the telescope eyepiece looks sharp when the eyepiece is adjusted for a sharp graticule image.

   DO NOT ALTER THE ALIGNMENT TELESCOPE FOCUS.

4. If the fibre image is not in sharp focus then a further small adjustment of the fibre input lens is necessary. Remove the rear module body. It will not be obvious which way the lens should be moved to improve the focus so begin by unscrewing the lens holder one quarter of a turn. Replace the rear module body and check sharpness of focus. If the image is less sharp then make any further adjustments in the opposite direction. If it is better then continue in the same direction. Continue to alternately adjust the lens and view the fibre until a satisfactory sharp focus is achieved. Next fully tighten the locking screw in the lens centering mount.

   Replace the rear module body and secure with screws (4).

5. Having set the axial position of the fibre input face to the correct position, the next step is to align the fibre laterally to the laser beam, again using the alignment telescope as reference. This adjustment is achieved by adjustment of the lateral position of the fibre input lens DO NOT ADJUST THE ALIGNMENT TELESCOPE.

   Adjust the input lens centering screws (4) located one in each face of the input module body, so that the image of the fibre-input face, seen in the telescope eyepiece, is accurately centered on the image of the graticule.

6. Ensure that all four centering screws on the input lens assembly are tight check that this has not degraded the alignment.

7. The FESM unit, including the fibre and input lens is now ready for use.

8. Remove any auxilliary illumination used at the output housing.

8.4.7 Adjustment of variable energy-share modules (VESM)

In many respects, the procedure to be followed with the VESM units follows closely the procedures used for the FESM. The main difference between the VESM's and the FESM is that on the VESM's the mirror can move and there is a knob to adjust the vertical position of the mirror.

Moreover, some of the procedures that were adopted for the FESM - principally, determination of the input lens focal plane (section 8.4.4) and setting up this alignment telescope (section 8.4.5) - do not need to be repeated. Indeed the SMM and the alignment telescope must not be re-adjusted, apart from setting the eyepiece for a sharp graticule image.

The preferred order of alignment, after aligning the FESM, is to align the VESM next to the FESM; then to align the VESM adjacent to the one just aligned; and so on that is, start with the FESM and work back through the modules from the FESM, towards the SMM. This order wastes less time and reduces the possibility of errors.

Thus the first VESM to be aligned is that adjacent to the FESM.

At this stage the mirror assembly, including the mirror slide, should not be fitted into any of the VESM's.

1. Remove the top cover-plate of the VESM to be aligned.

2. Remove the mirror assembly for the VESM from its protective wrapping, inspect the mirror for cleanliness and clean if necessary.

3. Orientate the mirror mount so that hole C (figure 5.2D) is at the bottom of the mount and insert a screw with washer and large flat washer under the screw head into hole C.

   Carefully lower the assembly through the aperture in the top of the VESM and secure the screw C, in its fixing hole, using an Allen key through the corresponding access hole in the front of the VESM partially tighten the screw so that the mirror assembly can be moved when pushed.

4. Next fit screws A and B (figure 5.2D) in the VESM base plate screw A will already be present with a wave-washer under the head of screw A and, in the case of screw B a wave-washer and a large flat washer under the screw head, and a 2mm thick shim between the mirror base plate and the VESM body.

5. Remove from the VESM (see figure 5.2C).

   - The front module body (3).
   - The input lens holder (4), after slackening 4 screws in the rear module body (2) which secure the lens holder.
   - Store the components in a safe clean place.

6. Secure the alignment jigs provided, in the ends of the alignment tube, with the spokes of the jigs inclined at 45° to each other.

7. The next step is to adjust the position of the VESM mirror mount and the front input module body so that the laser beam is centred on both alignment jigs, as far as possible. In order to check the alignment it is necessary to fire the laser.

   However first it is necessary to set the vertical position of the VESM mirror so that it intercepts and reflects the complete laser beam.

NOTE: When the mirror is at its lowest point of travel the position readout indicates 000. The travel needed to bring the mirror up to the required position will vary depending on the size of mirror fitted to your system and also the diameter of beam which is being used. In any case more than ten turns of the knob will be necessary, so the position readout will go through the 999/000 position and continue to increase. Therefore, in order to use the readout to give an indication of the absolute position of the mirror, it is necessary to know how many complete sets of ten turns have been made from the lowest position in addition to the readout value.

8. Then follow the procedure exactly as described in section 8.4.3, steps 7, 8, 9, and 10. Remember to tighten the fixing screws of the mirror assembly at the end of the procedure and then, to check that the alignment is still good.

   Remember to switch off the laser.

8.4.8 Alignment of fibre-assembly (VESM)

NOTE

This procedure relates only to VESM's which have been satisfactorily aligned as described in section 8.4.7.

Again this procedure parallels closely the equivalent procedure for the FESM (Section 8.4.6), with important additions relating to the variable position of the energy share mirror.

The main difference between the alignment of an FESM fibre and a VESM fibre lies in the potential confuson that can arise because of the presence of at least 2 fibres and 2 energy share mirrors in front of the alignment telescope.

Note that even if a VESM mirror only partially intercepts the laser beam path, it will still be possible to see a full image of the VESM fibre in the alignment telescope if the VESM fibre is illuminated at its output end.

Note too that if whilst the VESM mirror is in this position, the FESM fibre is illuminated then a full image of the FESM fibre will be seen.

Moreover if more than one VESM unit is present with mirrors and fibres in place then there is the possibility of seeing images of all the fibres.

It is therefore important to identify the output ends of the fibre assemblies correctly so that the correct fibre can be illuminated for alignment.

It is assumed that the VESM has just been aligned.

The next step is to re-assemble the input module and then attach the fibre assembly, if detached, and finally adjust the fibre/input module alignment using the alignment telescope.

1. Before proceeding with alignment as described for the FESM in section 8.4.6 adjust the VESM mirror to the position where it will intercept approximately half of the laser beam. Lower all other VESM mirrors (if present) to their lowest positions.

2. Proceed through section 8.4.6, steps 1 through to 8.

   Be sure to illuminate the correct VESM fibre at step 2.

   To align further VESM units proceed exactly as described in section 8.4.7 and 8.4.8 proceeding through the VESM's string with the one nearest the FESM and finishing with the VESM next to the SMM.

   If no TSM's are fitted the unit is now aligned and ready to be operated, if TSM's are fitted proceed with section 8.4.9

8.4.9 Adjustment of Time Share Modules (TSM)

The procedure to be followed with the TSM modules is very similar in principle to that used for the FESM and VESM (when fitted). The main difference is that the TSM mirror has two possible positions, in or out of the beam. For alignment purposes the mirror will be set in the upper position where it intercepts the beam.

Again the alignment telescope, having been set-up on the FESM must not be readjusted.

It is assumed that the mirror, mirror mount, backing plate, slide and slide mount may have been removed to fix the module body to the front of the laser rail. The fibre input module and TSM front plate will have been removed to achieve this. If this is not the case (ie where more than two TSM's are fitted) then follow the procedure from step 6.

The procedure is as follows:

1. Remove the top cover plate and gasket from the FESM.

2. Take the TSM mirror from its protective wrapping and inspect for integrity and cleanliness of the mirror surface. Clean the mirror surface if necessary.

3. Orientate the slide mount so that hole C (figure 5.2D) is at the bottom of the mount. Insert screw C in the mount with a wave-washer and large flat washer under the screw head. Carefully lower the assembly through the aperture in the top of the TSM and secure screw C in its fixing hole. Partially tighten the screw so that the mirror assembly can be moved laterally when pushed.

Next fit screws A and B (figure 5.2D) in the mount with a wave washer under the head of screw A, and, in the case of screw B, a wave washer and a large flast washer under the screw head, and a 2mm thick shim between the slide mount and the TSM body. Access these screws through the top of the TSM; tighten using a ballended Allen key.

4. Refit the backing plate to the slide (note that the backing plate remains inside the module fixed to the actuator push-rod).

5. Fix the mirror mount to the backing plate and remount the mirror. N.B. ensure that the coated face of the mirror is facing the beam.

6. Replace the front plate of the TSM and screw the front module body to it. Remove the rear module body and the imput lens assembly.

   Store any removal components in a safe clean place, ideally in plastic bags.

7. Secure the alignment jigs provided, in the ends of the alignment tube; with the spokes of the jigs inclined at 45° to each other.

8. The next step is to adjust the position of the TSM mirror mount and the front module body so that the laser beam is centred on both alignment jigs, as far as possible. In order to check the alignment, it is necessary to fire the laser.

   First set the mirror in the upper position so that it will intercept the beam. Then follow the procedure exactly as described in section 8.4.3 steps 7,8,9 and 10. Remember to tighten the fixing screws of the mirror assembly at the end of the procedure and then to check that the alignment is still good.

8.4.10 Alignment of fibre-assembly (TSM)

NOTE: This procedure only applies to TSM's which have been satisfactorily adjusted as described in section 8.4.9.

The alignment procedure parallels closely the equivalent procedure for FESM's (Section 8.4.6). Ensure that the mirror slide is still in the upper position, refit the input lens assembly and then proceed through steps 1 to 8 of section 8.4.6.

To align further TSM units proceed exactly as described in sections 8.4.9 and 8.4.10.

The unit is now aligned and ready to be operated.

8.5 Adjustment of energy-balance between fibres

Clearly the total output energy of the laser is determined by the demand parameters set on the laser control panel.

The combined output power of the fibres iwil be lower than the power output of the laser, owing to unavoidable losses, due to reflection

losses at the fibre end-faces and at the (uncoated) cover-slide in the output housing. In practice an overall loss of 15 - 20% should be anticipated.

The distribution of available power between fibres will be determined by the relative positions of the mirrors in the VESM's.

There are methods of setting the positions of VESM mirrors - trial-and-error, and using a power meter. Trial-and-error is a perfectly acceptable method in the case of a two-fibre energy-share system, since there is only one knob to set. However trial-and-error could prove time-consuming in the case of a 4-fibre system.

In this case, the preferred method would be to use a power meter as follows.

1. Identify the fibre corresponding to the VESM adjacent to the SMM (VESM1).

2. Set VESM1 so that the entire laser output will emerge from VESM1 fibre.

3. Set the power meter detection unit in line with the VESM1 output housing, separated by a minimum distance equal to 2 times the focal length of the focus lens in the output housing (see section 19). At this distance, the laser beam diameter is equal to the beam size at the focus lens.

4. Prepare the laser for operation (section 6.2.2). Wear suitable safety goggles.

5. Switch on the laser, open the shutter and note the power output reading. Then close the laser shutter.

6. Decide whether this power output is satisfactory for your proposed application. If not, modify the laser drive parameters as required to achieve the desired performance. Output power P (Watts), noting any power limits prescribed for your particular equipment.

7. Decide how you want to split the power P between say, four fibres

   e.g. $P = P1 + P2 + P3 + P4$

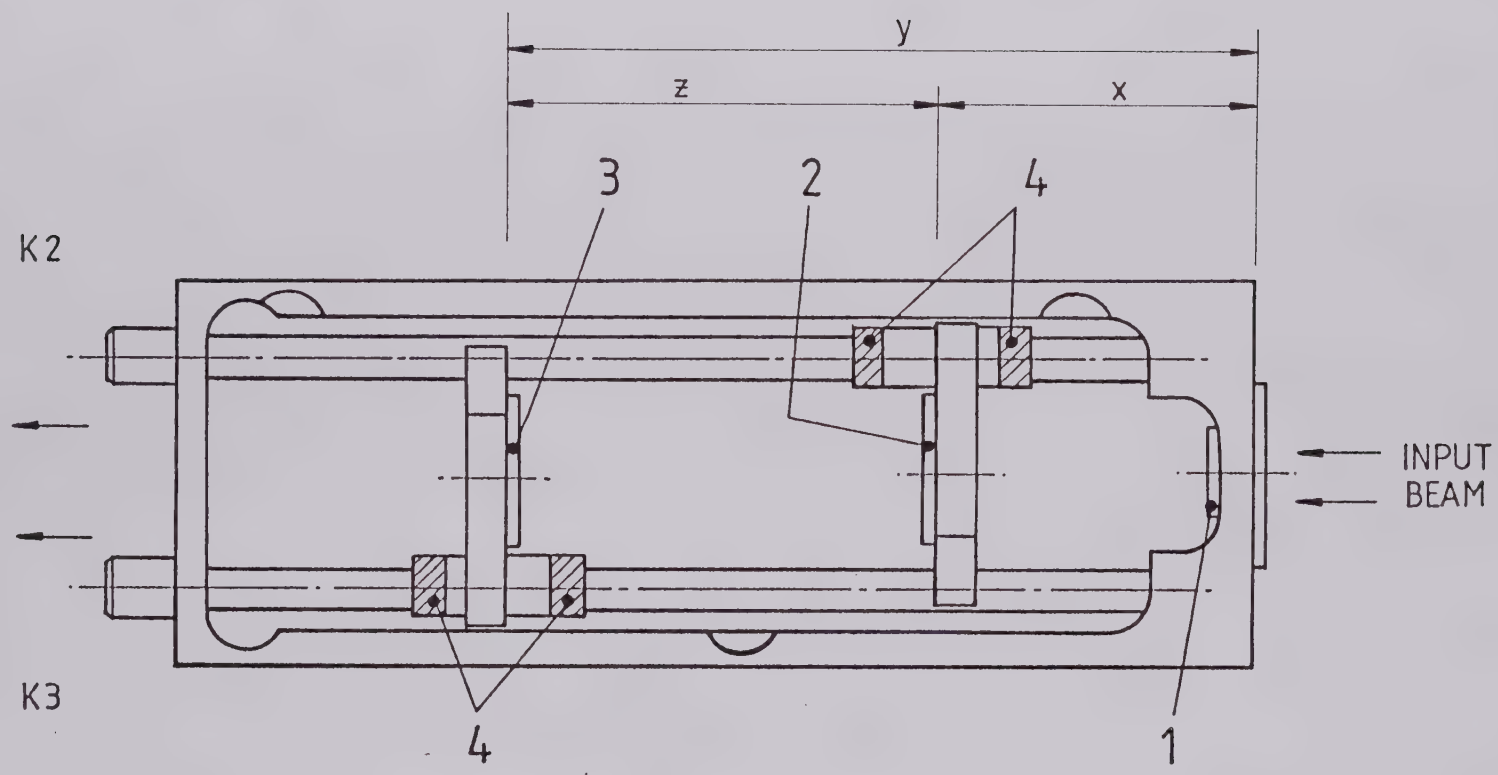
   Where Pn is the desired power output of fibre number n.

8. Switch on the laser again and set the position of the VESM1 mirror to achieve a measured output P1 watts.

9. Repeat steps 3, 4, 5 and 8 in turn for fibres 2 and 3 to achieve power output P2 from fibre number 2 and P3 from fibre number 3.

   P4 is not directly settable, being the balance remaining after P1, P2 and P3 have been extracted from the beam.

The desired energy-share distribution has now been achieved.



1. Input Lens
2. Centre Lens
3. Output Lens
4. Lens Carriage Clamps

K2. Adjuster Knob for position of Centre Lens (2)

K3. Adjuster Knob for position of Output Lens (3)

Fig. 8.3 SCHEMATIC OF JK700 BEAM EXPANDING TELESCOPE

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SECTION 9

SERVICE PROCEDURES

9.1 Introduction

9.2 Component Replacement Procedures

9.3 Replacement of Fibre Assembly

9.4 Replacement of Focussing Heads

9.5 Replacement of Output Optics

9.6 Realignment Following Component Replacement

9.7 Installation

9. SERVICE PROCEDURES

9.1 Introduction

1. All service procedures should only be carried out by Lumonics engineers or by customer's engineers who have received training on MULTIFLEX systems.

2. The only component which should require regular maintenance is the cover-slide fitted into each focussing head. The procedure for servicing cover-slides is detailed in Section 7.

3. This section indicates

   - where to find information as to how to remove/replace MULTIFLEX components
   - the extent of the realignment necessary after component removal.

4. ALWAYS DISABLE the laser (remove the ENABLE key) before carrying out any of the procedures.

9.2 Component replacement procedures

Information relating to the procedures for removing/replacing components may be found as follows.

Component	MULTIFLEX Manual Section
Laser components	(LASER Manual)
Steering mirror	5.2.4; 8.4.2
VESM mirrors	5.2.4; 8.4.7
FESM mirror	5.2.4; 8.4.3
TSM mirror	5.2.2; 8.4.9
Input coupling lens	5.2.4; 8.4.4; 8.4.6; 8.4.8
Fibre Assemblies	5.3; 8.4.6; 8.4.8
Alignment telescope	5.2.4; 8.4.5

9.3 Replacement of fibre assembly

NOTE: The fibre assembly should be handled with care in conditions which are as clean as possible.

To remove the fibre assembly from the input module, proceed as follows:

1. Remove the M4 screw securing the input ferrule into the input housing/focussing head.

2. Carefully withdraw the ferrule in a straight line.

3. Protect the ferrule by slipping a piece of clean plastic pipe of suitable diameter back over the nose of the ferrule; and tape a plastic bag over the ferrule to exclude dirt.

To refit a fibre assembly at the input end note that the alignment telescope must be set up again to provide a reference. DO NOT ASSUME THAT THE FIBRE CAN BE REPLACED WITHOUT RE-ALIGNMENT.

Repeat section 8.4.2 and 8.4.3 of the alignment procedure.

9.4 Replacement of focussing heads

1. The focussing head will usually be secured in a clamp. Before releasing the clamp and proceeding to withdraw the focussing head axially, check that this will not cause the fibre assembly to adopt an unacceptably low-radius bend. It may also be wise to put a pencilline on the focussing head, to facilitate replacement in the same position. Sometimes it will be necessary to remove the focussing head complete with its clamp then to lower the clamp off the focussing head to avoid severe bending of the fibre assembly.

2. Clean the focussing head in the region of the output ferrule to ensure that contamination does not enter either the focussing head or the protective collar of the output ferrule when the latter is released.

3. Release the screw securing the output ferrule to the focussing head.

4. Protect the output ferrule against contamination (tape a small clear plastic bag over it) and physical damage. Put it in a safe place.

5. Tape a clean plastic bag over the end of the focussing head to exclude dirt.

To replace a focussing head, proceed according to the above procedure, in reverse order. Remember to remove protective bags, tubes, tapes, etc.

9.5 Replacement of output optics

1. If possible, vacuum-clean the focussing head to prevent the ingress of dirt.

2. Remove the cover-slide retaining-ring and allow the cover-slide to drop out.

3. Removethelens cell by unscrewing it from the focussing head.

4. Select the threaded lens ring from the rear of the lens cell.

5. Supporting the rear lens with a clean lens tissue invert the lens cell and gently lower the two lenses and spacer from the cell.

6. Note the orientation of the lenses so that they can be replaced correctly. (Most curved faces of the lenses towards each other.)

7. To insert new lenses first ensure that they are clean, refer to Section 7.1.

8. Insert the lenses and spacer into the lens cell in the correct order. Fit the lens ring and screw home to secure the lenses. Do not overtighten.

9. Replace the lens cell in the focussing head and refit the cover slide and clip.

NOTE: Although the replacement lenses have nominally the same focal-length as the original lenses, the lens manufacturers generally quote a focal length tolerance of ±5%, together with a lens-centering tolerance. Consequently, the position of the fibre-image (ie the beam-waist, or region of maximum energy density) may be slightly different for the new lenses, necessitating a check on the alignment and distance of the focussing head from the workpiece.

9.6 Realignment following component replacement

Removal or replacement of the following components will necessitate realignment according to the sections of this Manual as indicated.

Component	Realign According to Sections
Laser Mirrors	8.4.2; 8.4.3; 8.4.5 - 8.5 inclusive
Laser BET	8.3; 8.4.2; 8.4.3; 8.4.5 - 8.5 inclusive
Steering Mirror	8.4.2; 8.4.3; 8.4.5 - 8.5 inclusive
FESM Mirror	8.4.6
VESM Mirror	8.4.7; 8.4.8; 8.5
TSM Mirror	8.4.9; 8.4.10
Input lens (FESM)	8.4.4; 8.4.6
Input lens (VESM)	8.4.4; 8.4.8
Input lens (TSM)	8.4.4; 8.4.10
Fibre Assembly (FESM)	8.4.6
Fibre Assembly (VESM)	8.4.8
Fibre Assembly (TSM)	8.4.10
Alignment Telescope	8.4.4; 8.4.5; 8.4.6

9.7 Installation

1) Carefully unpack the assembly from its crate and protective wrapping.

2) Blow/wipe any dust off the equipment.

3) If the equipment has been stored in a cold environment, do not remove any panels from the unit until it has reached room temperature.

The purpose of this is to avoid the formation of condensation inside the unit, particularly on the optics.

4) Read and digest this entire manual before proceeding.

5) Assemble and commission the laser.

6) Remove all protective tapes/wrapping off the unit and assemble it on the laser as described in section 8.4.2.

7) Proceed then as described in section 9.6 for replacement of the steering mirror; that is, perform an alignment checks as per section 8.4.3, 8.4.7 and if satisfactory proceed as indicated, omitting the procedure described in section 8.4.2.

SECTION 10

APPENDIX

10.1 Technical Data

10.2 Technical Changes

10.3 Special Equipment

10. APPENDIX

10.1 Technical Data

This section lists data specific to this system which is referred to from other sections of this handbook.

Laser type	:	JK701
Fibre size	:	600um
Fibre length	:	20m
Fibre part number	:	P44K9010B

Maximum average power permitted with this fibre and laser: 50 watts. System set up at 50 watts using the following setting parameters 5mS, 2Hz, 25J/pulse.

IMPORTANT: In some circumstances the system may be set up at a lower power than the maximum. In such cases the set-up average power must not be exceeded.

BET settings :-

d	=	16.5mm
d1	=	16mm
d2	=	17mm.
x	=	mm
y	=	mm
z	=	mm

Output Optics

1) Output housing assembly part No. : P44K9230C

Recollimating lens, focal length : 300mm part No. : 1231112YA

Focus lens, focal length : 200mm part No. : 1231033YA

Protection slide part No. : 123412301

Machining mirror part No. : 12220060A

Camera imaging lens, focal length: 100mm part No. : 1231063YA

BG 18 Filter part No. : 12300210A

2) Output housing assembly part No. : P44K8920C

Recollimating lens, focal length : 300mm part No. : 1231112YA

Focus lens, focal length : 200mm part No. : 1231033YA

Protection slide part No. : 123412301

10.2 Technical Changes

This section of the manual describes changes which have been introduced since the main body of the handbook was written.

10.2.1 Imaging Telescope Assembly

All JK700 series lasers to which an Energy-Share fibre system is fitted are now supplied with an imaging telescope assembly. This assembly consists of two lenses, one fitted in the laser process shutter and the other in an adjustable centering mount between the shutter and the BET. The function of this assembly is to eliminate any alteration in the size of the laser beam passing through the energy share system which might otherwise take place when the output power of the laser is altered. (Any change in beam size would alter the energy split between fibres).

The imaging telescope is factory set and should not require adjustment. However if necessary the centering adjustment on the second lens may be used to centre the laser beam accurately in the output port of the laser.

IMPORTANT NOTE: Under no circumstances should the centering adjustment be altered once the fibre system has been aligned or damage to the fibres may result.

10.3 Special Equipment

This section describes any special beam delivery equipment not covered in the main manual.

10.3 Special Beam Delivery System

10.3.1 General Description (Refer to fig. 1)

This system is designed to deliver the laser beam from a JK701 laser to any one of four fibre networks. This is achieved with the use of timeshare modules (TSM's) numbers one to three. When one of these timeshare modules is activated it will divert the beam upwards into the relevant fibre optic network. TSM1 directs the beam into network 2, TSM2 directs the beam into network 3 and TSM3 directs the beam into network 4. When all three timeshare modules are not activated the beam will pass into fibre optic network number one.

The system is only being supplied with fibre optic networks numbers one and two. The remaining two networks and associated timeshare modules (2 & 3) can be fitted at a later date as required. When timeshare modules 2 & 3 are not fitted a flight tube that goes from the laser to timeshare module 1, must be fitted in their place.

Fibre optic network 1 consists of a 4-way energy share unit and a timeshare module (TSM4). Fibre optic network 2 consists of a 2-way energy share unit and a timeshare module (TSM5). The laser beam can therefore be switched between a 4-way energy share, a 2-way energy share or one of two single fibres, connected to TSM4 and TSM5 respectively.

All units are built onto a common support structure that attaches to the laser front plate via 8 screws and braces back to a special baseplate supporting the laser head.

The system is supplied with 20 metre long 600um diameter fibres with straight and right angled output housings.

10.3.2 Laser Resonator Configuration

To provide the laser beam quality required, to focus the laser beam into the fibre optics, a change to the standard laser resonator is required.

To familiarise yourself with the JK701 resonator optics refer to Section 4.2.3 and figure 4.2F of the JK701 manual.

The change required is a modification to the standard or 'welder' resonator. The rear mirror clip and rear mirror assembly M1 is moved back to the farthest set of mounting hole (as for the JK701 LD1, see figure 4.2F). The silver beam tube and adaptor provided in the FOBD accessory kit fits in between the rear mirror and the pumping chamber.

The resonator can now be aligned as described in section 9.2.2.

Note: This resonator should not be run at an average power exceeding 120 watts as above this it becomes unstable. This will not cause a problem under normal operation because the maximum average power permitted with the fibre system is 50 watts (see Appendix 10.1 of this manual).

10.3.3 Alignment Procedure

IMPORTANT: Prior to powering up the associated laser, and operation of this equipment, it is important to read ALL sections of this manual to familiarise yourself with the equipment, PARTICULARLY section 6.1 (Precautions) and section 6.2 (Operating Instructions).

All burn patterns must be taken on burnpaper with a superimposed protective glass slide. The slide must be held square to the laser beam to prevent exposure of nearby personnel to laser radiation reflected off the slide.

1) Laser Beam Collimation

Before the laser beam collimation can be checked or adjusted fibre optic network 1 must be removed from the support structure and the timeshare modules 1,2 and 3 (where fitted) should also be removed from the structure or configured so that they do NOT intercept the laser beam.

The procedure for setting up the laser beam expanding telescope (BET) should now be followed as covered in Section 8.3, including the following amendment:

With reference to section 8.3 step 6 the single shot burn patterns should now be taken 550mm, 650mm, 750mm and 850mm from the front face of the laser.

Special note should be taken of the warnings given in Section 8.3 step 5, particularly:

".....you should be wearing safety goggles which are designed to protect against exposure to a class 4 laser of 1060nm wavelength."

and

"Before firing the laser you should ensure that everyone in the vicinity is also familiar with the safety requirements."

2) Beam Centring

It is necessary to centre the laser beam through TSM's 1 to 3. To achieve this TSM1 must be fitted and if TSM2 and 3 are fitted they should be configured so that they do not intercept the laser beam. Prepare the laser beam for operation. LASER SAFETY GOGGLES MUST NOW BE WORN.

TSM1 must also be configured so that its own mirror does not intercept the laser beam and the alignment aid provided should be fitted in its output port. A single shot burn pattern must be taken close to the alignment aid and the centring of the cross image can be checked. To centre the cross image on the laser burn the x,y adjustment screws can be used on the imaging telescope centring mount (see section 10.2.1).

3) Adjustment of Timeshare Modules (TSM1,TSM2 and TSM3)

The timeshare modules need to be adjusted to aim the laser beam up into the centre of the steering mirror modules (SMM) fitted to the fibre optic networks. The timeshare modules must be fitted and aligned in order, starting with the one nearest to the laser front face (TSM3 when required). This is because when TSM2 and its flight tubes are fitted, TSM3 cannot be removed. In the same way TSM1 will prevent TSM2 from being removed. Each module is held in place by four screws that pass through the faceplate of the timeshare module and into the support plate.

To align the TSM the relevant fibre optic network and its vertical flight tube should be fitted to the support structure (refer to section 8.4). Remove the steering mirror assembly from the steering mirror module (SMM) and store it in a clean plastic bag, taking care not to make contact with the mirror face. The alignment adaptor and alignment aid will now fit into the beam entry hole of the SMM and will drop down so that it rests on the steering mirror adjustment screws (see figure 10.2).

The following alignment procedure is based upon that described in section 8.4.9. of this manual. For alignment purposes the mirror in the relevant TSM should be positioned so that it intercepts the laser beam.

Three types of adjustment are required for aligning the laser beam; two of these adjust the tilt of the TSM mirror mount. The mirror baseplate is secured in the TSM by screws A,B and C (see figure 5.2D). Screw A passes through a close fitting hole in the baseplate; screws B and C through oversize holes. The baseplate can therefore be rotated in its own plane about screw A which acts as a pivot.

The second method of tilting the mirror mount is to fit one or more pieces of shim (thin u-shaped metal washers) between the mirror baseplate and the TSM body at screw B. Shims of various thicknesses are included in the accessory kit provided with your Multiflex unit.

Rotation of the mirror base plate about screw A will move the reflected beam in an arc parallel to the front face of the laser.

Conversely fitting shims under the mirror baseplate at screw B will move the reflected beam in an arc at 90 degrees to the previous axis.

NOTE that since the shims provide angular adjustment in steps it will not be possible to achieve perfect alignment. However, by making use of the range of shim thicknesses provided the residual error can be minimised.

Prepare the laser for operation. LASER SAFETY GOGGLES MUST BE WORN.

To adjust the rotation of the mirror baseplate the timeshare module should be removed and screws A,B and C loosened. Estimate the centre position of the baseplate rotation and lock the three screws. Refit the timeshare module to the support structure and take a burn pattern just in front of the alignment aid fitted in the SMM.

Look at the burnpaper with the end that was inside the SMM held uppermost.

If the cross image is high on the laser burn then the mirror baseplate should be adjusted anticlockwise when viewed from the top. If the cross image is low then adjust the mirror baseplate clockwise.

To do this remove the timeshare module, loosen screws A,B and C then make a small adjustment in the required direction. Tighten the screws, replace the timeshare module and repeat the operation.

Adjustment of the shims is done in a similar way. With the timeshare module removed, screws A and B can be loosened so that the shims can be removed and replaced beneath screw B. With the burnpaper held as before, if the cross image is too far to the left shims should be added. If the cross image is too far to the right shims should be subtracted.

The third method of adjustment is now carried out by loosening the 4 clamp screws and rotating the TSM on the freeplay in the holes. This will give a similar axis of adjustment to the rotation of the mirror baseplate. Once aligned the TSM mounting screws should be firmly tightened.

NOTE: When all of the relevant TSM's have been fitted and aligned check that all flight tubes are clamped in place, thus fully enclosing the laser beam.

4) Alignment of fibre optic networks

With the TSM's 1 to 3 (where required) fitted and aligned the fibre optic networks can be aligned. The networks are made up of a combination of standard energy share and timeshare modules, alignment of which is covered from section 8.4 onwards in this manual.

The following amendments to sections 8.4.4, 8.4.5 and 8.4.6 must be followed.

Ignore section 8.4.4 steps 13,14 and 15.
Ignore section 8.4.5 step 1,2,3 and the introduction.

Replace these steps with the following instructions:

Identify the setting ring in the accessory kit, it has the same diameter as the film holder.

Insert the ring into the KFM first followed by the film holder (usual orientation). Push the film holder in with a ruler so that you can monitor the insertion depth. Push the filmholder in to the depth where the smallest hole in the Kapton foil was achieved (refer to section 8.4.4 step 12).

Secure the ring in place using the relevant grubscrew in the KFM.

Check that the insertion depth of the film holder is optimum, when pressed against the setting ring. Then secure the film holder in place (1 grub screw).

Proceed with section 8.4.5 step 4 onwards.

After section 8.4.5 step 11 has been completed and the KFM has been removed, the position of the focus lens can be coarsely adjusted to bring the minimum beam diameter into the same plane as the fibre. The end of the fibre, when fitted, will be at a position equivalent to a depth of insertion of 20.5mm. Subtract 20.5mm from the depth of insertion determined in section 8.4.4 step 12. This is the amount by which the lens must be adjusted. If the depth of insertion is greater than 20.5 the lens is screwed out, if less it is screwed in.

Unscrew the threaded lens holder until it has moved, relative to the centring mount, by the required amount of adjustment. (take a measurement between the rear of the lens holder flange and the centring mount to check).

Proceed with the rest of the setting-up instructions from Section 8.4.6 onwards.

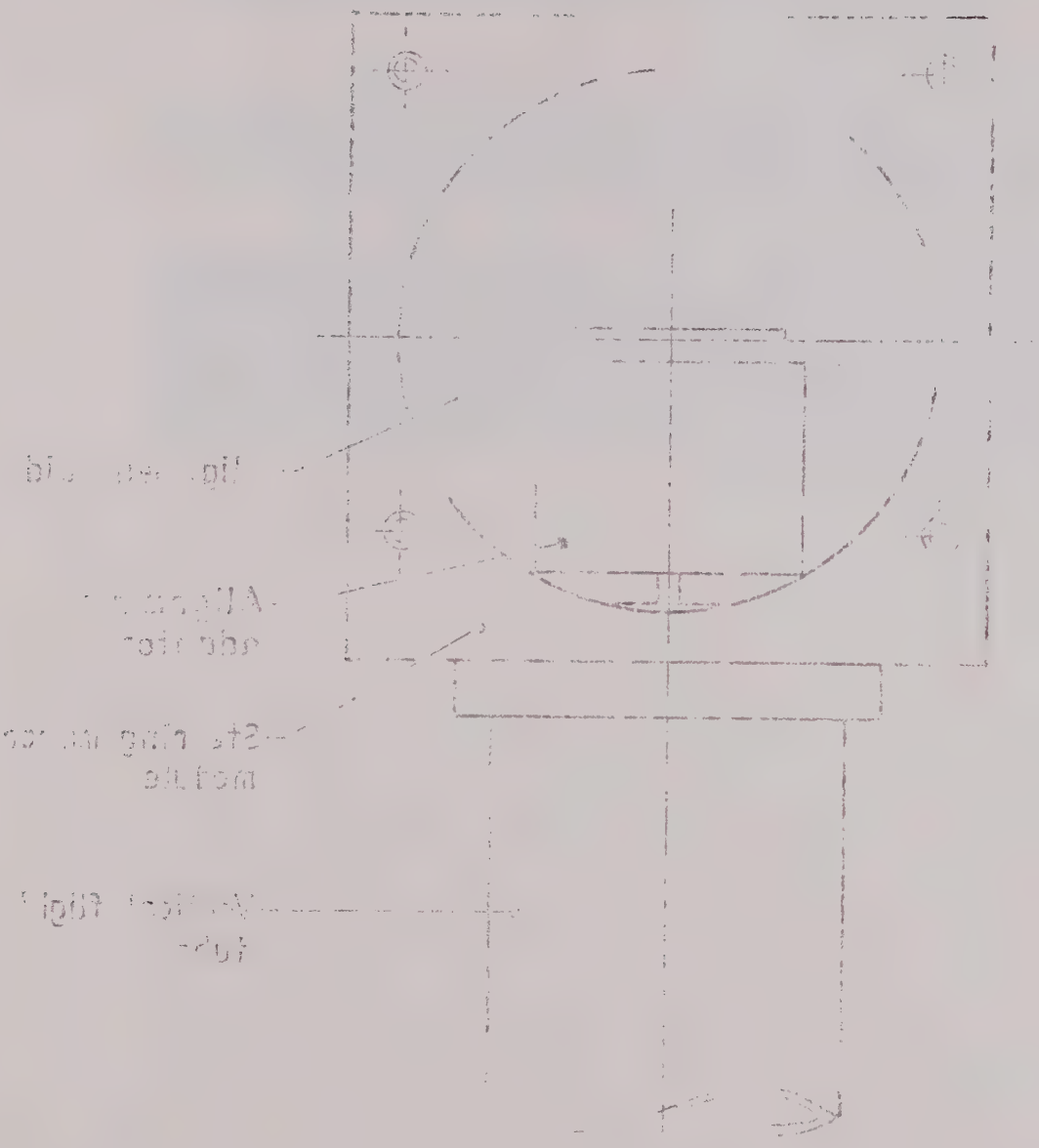
WARNING: Eight fibre optic inputs are provided on the fibre optic networks, but only seven fibre optic assemblies are provided. The input that does not have a fibre fitted must have the blanking plug provided fitted in its place. This input must not be selected by the control system.

IT IS ESSENTIAL THAT THE EQUIPMENT IS NEVER ROUTINELY OPERATED WITH UNPLUGGED APERTURES OR OPEN BEAM PATHS.

10.3.4 Output housings

Two types of output housings are provided with this system. The first is a straight output housing that is 57mm diameter and fitted with a 300mm recollimating lens (L1) and a 200mm focus lens (L2). (This housing is similar to that shown in fig 5.4).

The second is a 90 degree output housing fitted with the same focussing and recollimating optics (see fig. 10.3). A CCD camera can be fitted to the camera mount so that it views through the machining mirror and focussing optics. The focal plane of the camera can be adjusted to match that of the laser beam by screwing the camera mount in and out of the housing. When a sharp image has been obtained the locking ring can be tightened to prevent movement of the camera mount.



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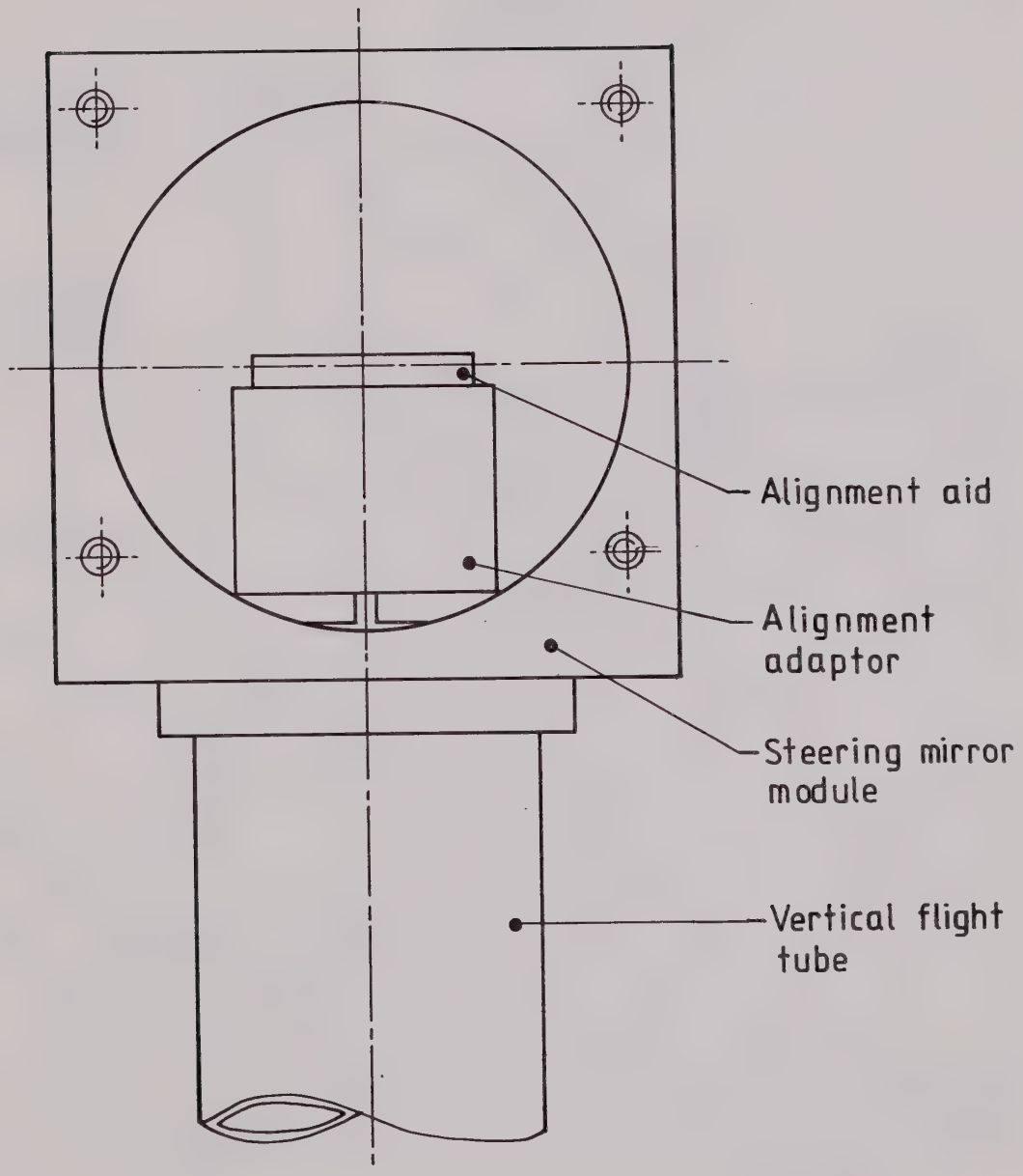

FIG. 10.2 – ALIGNMENT AID LOCATION

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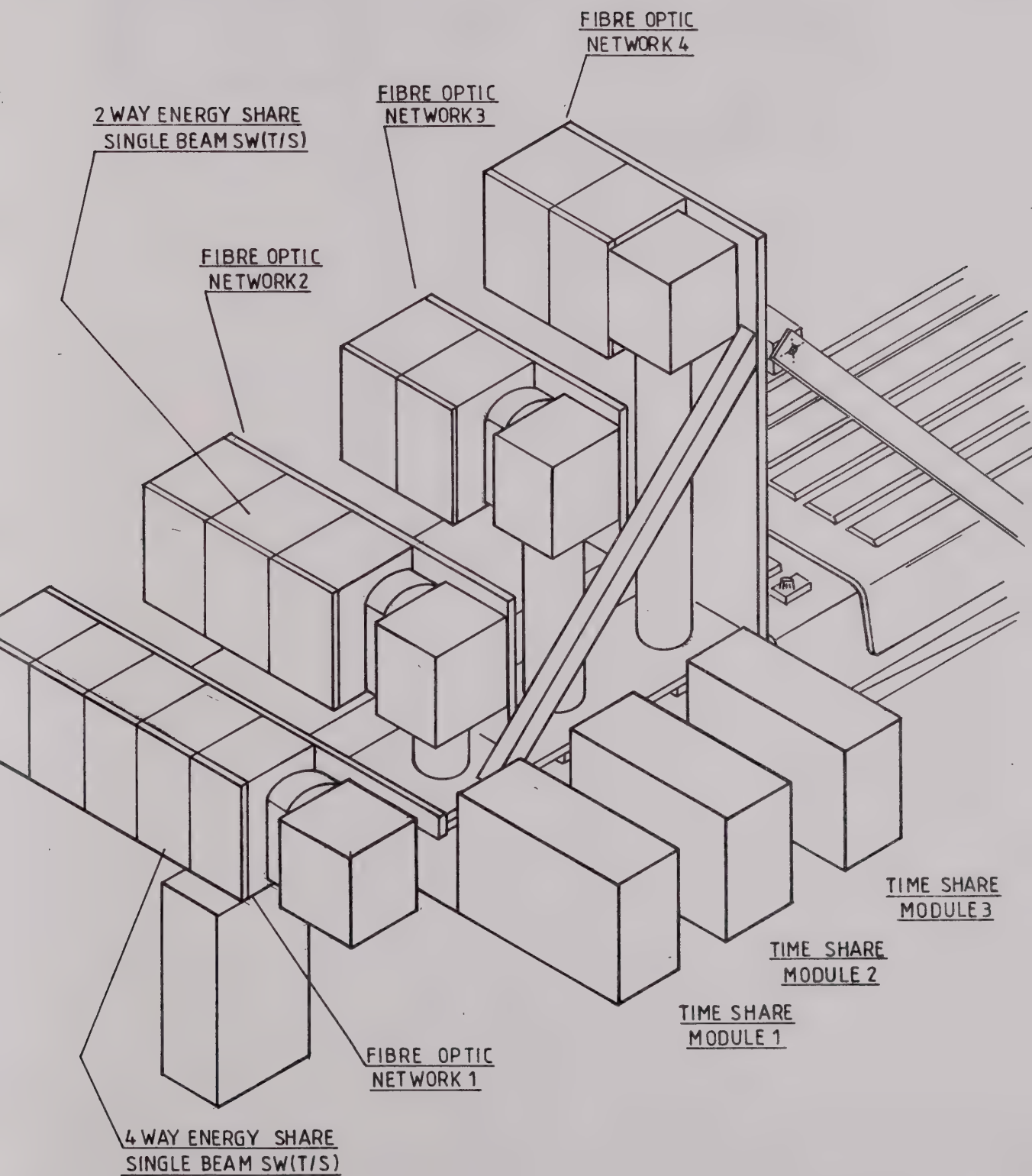
FIBRE OPTIC NETWORK 4
FIBRE OPTIC NETWORK 3
2 WAY ENERGY SHARE SINGLE BEAM SW(T/S)
FIBRE OPTIC NETWORK 2
TIME SHARE MODULE 3
TIME SHARE MODULE 2
TIME SHARE MODULE 1
FIBRE OPTIC NETWORK 1
4 WAY ENERGY SHARE SINGLE BEAM SW(T/S)

FIG. 10.1

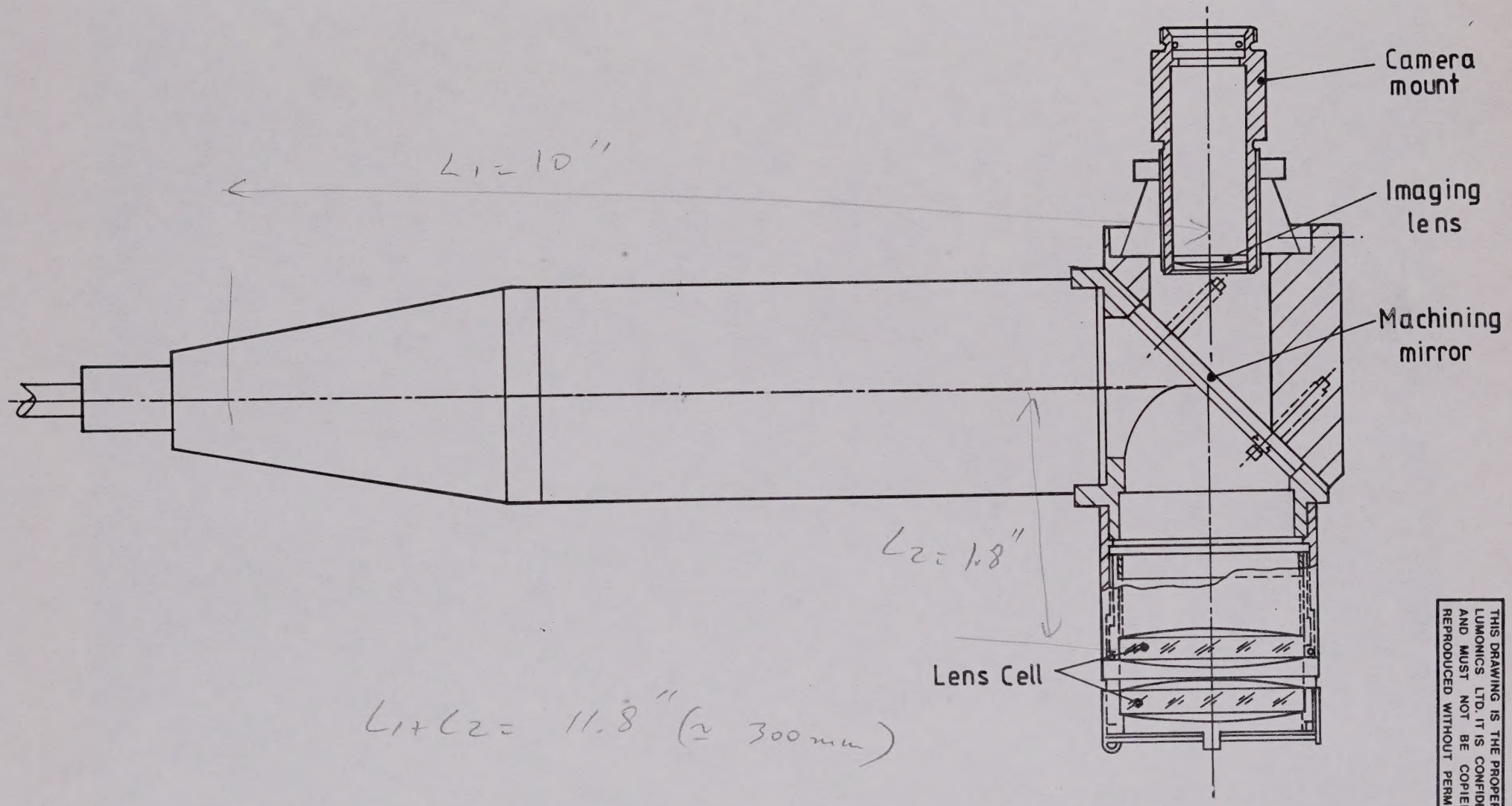

FIG.10.3 FOCUSSING HEAD

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